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Estimating Seed Vigor by Sugar Exudates and Radicle Elongation

James P. Barnett

Principal silviculturist, USDA, Forest Service, Alexandria Forestry Center, Pineville, LA

*Sugar exudates and radicle growth were evaluated as techniques to estimate the vigor of longleaf (*Pinus palustris *Mill), spruce (*P. glabra *Walt.), and loblolly (*P. taeda *L.) pine seeds. The effectiveness of these methods varied considerably by species. The reliability of sugar exudates as an index of germinability was better for species with softer seedcoats. Seeds with harder coats were apparently less permeable to the passage of exudates that may have resulted from cell wall degradation. The use of radicle elongation as an index of vigor seemed equally as variable.*

As seeds deteriorate and lose viability, their cell membranes break down and allow internal substances to leak out. Heat-killed embryos of sugar pine (*Pinus lambertiana* Dougl.) have greater rates of solute leakage than do viable seeds (9). Pitel (10) demonstrated that increased periods of accelerated aging of jack pine (*P. banksiana* Lamb.) seeds resulted in increased conductivity of the soak water. Hocking and Etter (5) reported a close correlation between germination of white spruce (*Picea glauca* [Moench] Voss) and the sugar concentration in the seed leachate. This relationship of leached solutes and field emergence was first demonstrated for peas (*Pisum sativum* L.) (8). Later research has supported this principle, and electrical conductivity of seed leachates is now included in the International Seed Testing Association's Handbook of Vigour Test Methods (6). Bonner and Vozzo (3) have reported that measurement of leachate conductivity provides valid estimates of seed quality of loblolly (*Pinus taeda* L.) and slash (*P. elliottii* Engelm.) pine.

If exudates can be used to reliably estimate seed viability, they may also be of value in evaluating vigor. Such an indicator of seed vigor is needed, and none of consistent reliability has been developed for pine seeds. One that has been used with seeds of other genera is early seedling development. Although epicotyl growth is normally measured, root growth has also been related to seed vigor (7, 11). Root development would seem to be the better parameter to measure in pines because epicotyl growth is usually slow.

This paper discusses an evaluation of sugar exudates and radicle growth as techniques for estimating the vigor of seeds of longleaf pine (*P. palustris* Mill.), spruce pine (*P. glabra* Walt.), and loblolly pines.

Methods

Twenty-seed lots of longleaf pine and 10 each of loblolly and spruce pine, selected for a range of germinability, were divided into 6 sublots for evaluation of sugar exudates. Empty seeds were removed from the lots before use. One-gram samples from each species-replication were placed in test tubes and surface-sterilized by adding 2 milliliters of 0.1 percent calcium hypochlorite. After soaking for 10 minutes, the seeds were rinsed and 15 milliliters of distilled water was added. The tubes were then capped and allowed to stand for 24 hours at room temperature (24 + 2 °C). After this imbibition period, duplicate analyses for sugars were run by the phenol-sulfuric acid method described by Dubois et al. (4). The percentage of transmittance of the resultant mixture was read on a spectrophotometer at 490 nanometers.

Duplicate 100-seed samples from each species treatment replication were tested to determine percentage of germination. All tests were conducted in a seed testing laboratory according to test procedures of the Association of Official Seed Analysts (1). Seeds of longleaf and spruce pine that had germinated (radicles extended) in these tests were used to estimate vigor by measuring radicle growth. When sufficient numbers were available, about 10 seedlings from seeds that had germinated on the same date were used to measure radicle growth to the nearest millimeter. These measurements were made about 4 days after germination began.

After the correlations between germination and percentage of transmittance of the exudates were made, 10 additional lots of longleaf pine were used to evaluate the accuracy of the estimates obtainable with the technique.

Results and Discussion

Statistically significant (P = 0.05) correlations between germination and reacted sugar exudates in longleaf and spruce pine indicate that this technique has potential for quick estimation of seed quality. Correlation coefficients of 0.820 and 0.851 were obtained for longleaf and spruce pine, respectively (fig. 1). However, the number of seed lots represented was not sufficient to cover a wide range of viabilities of spruce pine. Even in longleaf pine, where a wide range of viability was represented, verification with other seed lots showed that the predictability of germination by measuring transmittance of the reacted sugar exudates was poor. Actual percentage germination was as much as 44 percentage points different from the predicted values (table 1). The error was greater when viability was high and was too great to reliably estimate seed quality. Variability among replications was quite large, with at least six replications

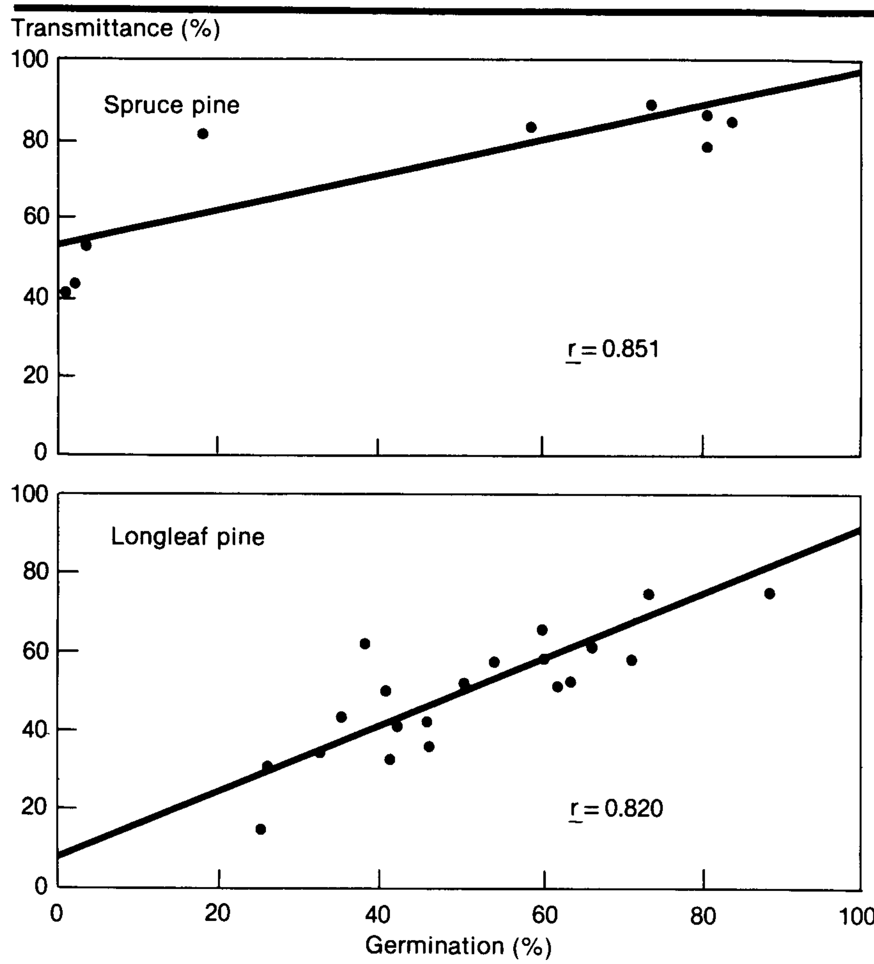

Figure 1—*Relationship of germinability of longleaf and spruce pine to transmittance of seed exudates.*

being required to provide consistent data.

The tests with loblolly pine were completely negative; no colorimetric changes of leachates occurred following the 24-hour imbibition period. The trends established in this study indicate that the effectiveness of leachate evaluations as indices of seed quality may vary by species, depending upon the thickness of the seedcoat or perhaps the size of the seed. Earlier work has shown that seed coats consist of nearly 60 percent of total dry weight in loblolly pine, but less than 30 percent in longleaf seeds (2). The other southern pines fall between these two extremes.

Table 1—*Average transmittance of reacted exudates, radicle length, and both actual and predicted germination of longleaf pine seeds (N = 20)*

Lot number	Percent transmittance	Percent germination		Radicle length[1] (cm)
		Predicted	Actual	
1	9	0	0	ND
2	33	29	73	1.3
3	35	32	10	ND
4	14	6	6	ND
5	66	70	71	1.6
6	50	50	90	1.5
7	75	80	94	1.5
8	72	77	96	1.3
9	72	77	96	1.0
10	66	70	98	1.8

[1] ND = not done; germination was so sporadic that radicles were not measured.

Bonner and Vozzo's evaluation of leachate conductivity indicates that viability of slash pine can be more accurately predicted than that of loblolly pine (3).

Correlations of germination to radicle growth were statistically significant with spruce pine (r = 0.981) (fig. 2), but no relationship was found with longleaf pine (r= 0.064). The data for spruce pine are so limited that this procedure cannot be recommended at this time. Further evaluations will be needed to develop the potential of this technique fully.

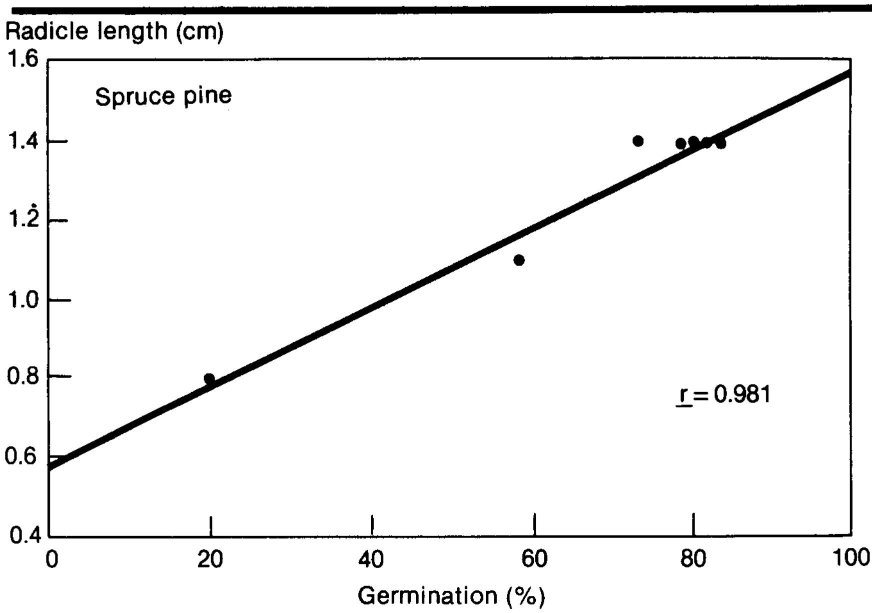

Figure 2—*Relationship of radicle growth to germination of spruce pine seeds.*

Conclusions

These tests indicate that both seed leachates and early radicle growth may have potential as indicators of seed quality. However, neither parameter seems sufficiently reliable to be of practical significance at this stage of development. Electrical conductivity measurements of conifer seed leachates have been developed with greater reliability because commercial equipment is now available for use (3). A major problem in the evaluation of all leachate techniques is the difference in response among species. Focusing on individual species should increase the progress in developing effective seed quality tests.

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