EFFECT OF MOISTURE CONTENT ON THE ASSESSMENT OF WOOD QUALITY FOR KNOWN-SOURCE GENETIC MATERIAL

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ABSTRACT: The study material was sampled from a red pine progeny test/seedling seed orchard machine planted with 3-0 planting stock at 1.8 x 2.4 meter spacing in Central Wisconsin in 1970. It contains over 300 four-tree row plots per replication following the randomized complete block design. Only 25 families were selected in the present study for which the degrees of freedom were 24, 4 and 96 respectively for family, blocks and error. A one-inch thick circular-shaped disk specimen was cut at 0.2 meter from the ground from each of 125 sample trees in 1980. The wood specimens were debarked and ovendried to arrest mold development. They were then immersed completely under fresh water to ensure their green wood condition for 1, 2, 3, 4, 5, 6, 7, 8, 10, and 15 weeks; at the end of each immersion period, I determined their green volume and specific gravity. Each set of wood data was subjected to an analysis of variance. Family means were used as items in the simple correlation analysis correlating between wood properties evaluated at the different immersion periods. The wood properties obtained after 15 weeks of immersion were compared with those obtained at the shorter periods. The correlation coefficients were 0.989 or greater for the green volume and 0.991 or greater for wood specific gravity. Three to five weeks of fresh water immersion was suggested to bring the disk wood specimens from air/oven-dry to green wood condition for the purpose of the genetic assessment of wood quality.

Specific gravity is an important wood quality and receives extensive studies for a number of tree species. It is a good indicator for pulp yield per unit volume of dry wood substances and has a direct bearing on the mechanical properties of the wood. Furthermore, it is under a strong genetic control (Zobel, 1961) and the improvement for wood quality through selection breeding can be very effective. It is expressed as a ratio of ovendry weight to green volume of the wood. The green volume varies with the amount of the moisture present in the wood and consequently affects the determination of wood specific gravity.

Dealing with the small-sized wood specimens such as increment core sample, Smith (1954) suggested that wood specific gravity should be determined under the similar or uniform green wood (moisture content) condition for all wood specimens by simply saturating them in water to reach the maximum moisture content. However, the job is more tedious and time consuming when the specimens are large in size (such as the disk specimens removed at the breast high position along the trunk) and numerous in number (tens of thousands) frequently confronting many tree improvement workers. An acceptable alternative technique needs to be worked out.

The present paper studies and analyzes the impact of the various moisture contents in the wood on the evaluation of the genetic information on wood specific gravity in red pine (*Pinus resinosa* Ait.).

MATERIAL AND METHODS

In 1970, a red pine seedling seed orchard was established in Wisconsin Rapids, Wisconsin with 3-0 planting stock grown from seed collected from 310 wind pollinated families in 46 natural stands throughout Wisconsin. It was machine planted at 1.8 x 2.4 meter spacing in the replicated randomized complete block design. Each family was represented by a four-tree row plot per replication. The orchard was thinned in 1980 and only one tree per plot was selected from which a one-inch thick disk specimen was sampled at 0.2 meter above the ground. Only 25 families were selected from each of 5 replications; altogether 125 disk specimens were included in the present study. All disk specimens were debarked and ovendried to arrest mold development and for storage until December 1983.

Starting January 1984, the wood specimens were placed in a 10-gallon size container and immersed completely under fresh water for 1, 2, 3, 4, 5, 6, 7, 8, 10, and 15 weeks to restore their green wood conditions. At the end of each immersion period, I removed the wood specimens and determined their green volume according to the method proposed by Heinrichs and Lassen (1970). The ovendry weight was determined only once at the termination of the 15-week long experiment. The weight of the ovendry as well as the green wood while submerged in water and while in air was obtained by a Mettler's balance to the nearest 0.1 gram. Alcohol-benzene extractives were not removed from the wood sample.

An analysis of variance was performed on each set of wood properties for which the degrees of freedom were 24, 4 and 96 for family, blocks and error respectively. Mean green volumes and mean unextracted specific gravities based on 5 replications were used as items in the simple correlation analysis (with 23 degrees of freedom) to learn if the changes in family ranks occurred in response to the various immersion periods.

RESULTS AND DISCUSSION

There were no significant differences in green volume and unextracted specific gravity among the 25 selected red pine families (Table 1).

Table 1. No significant differences in mean wood properties obtained at various water immersion periods

Weeks of	Green Volume		Specific Gravity	
Immersion	F values	cc	F values	Number
1	1.257	141.75	0.659	0.416
2	0.990	142.50	0.643	0.414
3	1.250	142.24	0.650	0.412
4	1.251	143.68	0.693	0.410
5	1.251	143.50	0.954	0.411
6	1.202	143.77	0.954	0.410
7	1.202	143.84	0.953	0.410
8	1.201	143.92	0.954	0.409
10	1.242	143.34	0.659	0.411
15	1.246	143.55	0.698	0.411

$F_{.95}$ (24/96) = 1.646

$F_{.99}$ (24.96) = 2.018

Working with over 300 families collected throughout Wisconsin, Agar, et al (1983) concluded that red pine was genetically uniform in wood specific gravity and other growth traits.

An important component in the specific gravity formula is green volume in cubic centimeters. The green volume is further governed by the amount of the moisture content in the wood. For accurate results, all specimens should be evaluated under the uniform moisture content. This condition can be satisfied by the maximum moisture content technique developed and proposed by Smith (1954). All specimens are to be placed in a vacuum flask or container, fill it with distilled water and a vacuum applied to ensure that the sample is absolutely saturated. The technique requires only determination of the weight of the completely water saturated sample and the weight of the ovendry sample. The technique works well on the small-sized sample such as increment core or portion of the core sample.

The genetic assessment of wood quality necessitates measurement of many wood specimens frequently by the thousands. This problem may be confounded if one decides to use circular-shaped disk specimens to serve one's research purpose. Because the disk specimens are far larger in size than the increment core sample to be placed in the vacuum flask, an alternative technique needs to be sought to solve the problem.

Obviously, the wood specimens start to respond to the surrounding atmospheric condition and their moisture content begins to fluctuate once they leave the living tree. The variation in the wood moisture content may contribute to an increase in experimental error and every effort must be made to improve the uniformity in the wood moisture content or green volume.

When handling thousands of wood specimens, the determination of wood properties requires over an extended time period and mold development is likely to occur if they are stored under an improperly aerated room. The mold is undesirable in the study of any wood properties.

It appears appropriate to air or ovendry the wood sample immediately after field sampling. Thoroughly dried wood sample withstands storage and the restoration of the green wood condition and the determination of wood properties can be accomplished at any convenient time. Though the acceptable length of water immersion should be worked out in accordance to the tree species and the size of the wood specimens to be used in the study. Throughout the 15 weeks of water immersion, mean green volumes did not change significantly (from 141.75 to 143.92 cubic centimeters, a difference of only 1.5 percent). This was associated with a negligible change in mean specific gravities from 0.416 to 0.409, a difference of 1.7 percent.

The number of the wood specimens fully saturated and sunk to the bottom of the container was recorded at the end of each water immersion period. Of the 125 disk specimens, only 1 sank after a week of soaking; the number increased to 8, 17, 36, 55, 71, 83, 97, 109 and 120 after 2, 3, 4, 5, 6, 7, 8, 10 and 15 weeks of immersion, respectively. Nearly one half of the total wood sample reached their maximum moisture content and sank in 5 weeks of immersion. When the experiment was terminated after 15 weeks of water soaking, 96 percent of the wood sample had become water saturated. The wood properties obtained after the 15-week immersion were therefore considered as standard, and they were used to correlate with those evaluated at the shorter immersion periods. The correlation coefficients were 0.989 or greater for the green volume and 0.991 or greater for wood specific gravity, all statistically significant at the 1 percent level (Table 2). This may indicate that the ranks in family means remained unchanged regardless of the immersion periods applied.

Table 2. The correlation coefficients between wood properties obtained at various water immersion periods

Various weeks of Immersion in water	Green volume	Specific gravity
15 vs 1	0.999	0.998
2	1.000	0.999
3	0.989	0.999
4	0.999	0.991
5	1.000	0.999
6	1.000	0.999
7	1,000	0.999
8	1.000	1.000
10	0.997	1.000

$r_{.95}$ (23 d, f.) = 0.396

$r_{.99}$ (23 d. f.) = 0.505

Because red pine is genetically uniform in wood properties, it was not possible to compute the size of the genetic variance component as affected by the water immersion periods. However, it was feasible to monitor the changes in the size of the experimental error variances (corresponding to 96 degrees of freedom). The error variance resulting from an analysis of variance was used to compute the standard error of plot mean (since only one tree per plot or per family per replication was sampled, plot mean actually represents a single measurement) , the coefficients of variation and the sample size needed to achieve the desired degrees of precision. The results are presented in Table 3.

Table 3. The relationship between water immersion periods and sample size based on specific gravity data

Weeks of Immersion	Standard error	Coefficients of variation	Sample size
1	0.032	0.169	46
2	0.032	0.169	46
3	0.032	0.169	46
4	0.032	0.172	48
5	0.178	0.967	1,476
6	0.178	0.966	1,474
7	0.177	0.966	1,474
8	0.177	0.969	1,482
10	0.032	0.172	48
15	0.032	0.172	48

There are three stages in the standard error curve. This is obtained by plotting the standard errors against the immersion periods. Stage I covers the first four weeks of immersion and is characterized by the steady but small standard errors. Stage II corresponds to the following 4 weeks (weeks 5 through 8) of immersion and is marked by a sharp rise or increase in the size of standard errors. The cause of the increase was not determined; however, it is translated as a need of 30 to 35 folds in the working sample size to achieve the identical degrees of precision in the experiment. Stage III is featured by the decrease and return of the size of standard errors back to what it was during the first 4 weeks of immersion. This was perhaps attributable to reaching uniform wood moisture content by many wood specimens. At Stage Ill , over 80 percent of the wood sample had become saturated and had reached uniform green wood conditions.

CONCLUSION

A complete immersion under fresh water of air/ovendry disk wood sample for three to five weeks seemed adequate to restore the required uniformity in green wood condition (or moisture content) for the study purpose of specific gravity. The proposed technique only requires a large container (a 10-gallon size drum for example) and a balance for measurement of the ovendry weight as well as the wet (green) weight of the wood sample while submerged in water and while in air.

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