The Effect of the Method of Cutting on the Moisture Content of Samples from Tree Branches

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# THE EFFECT OF THE METHOD OF CUTTING ON THE MOISTURE CONTENT OF SAMPLES FROM TREE BRANCHES [1]

J. Joseph McDermott

The moisture content of the woody structure of trees is often ascertained by use of twig segments. If the water in the xylem elements is under tension, any cut which ruptures the continuous water columns might be expected to result in the almost instantaneous removal of water from the xylem elements in the vicinity of the cut. If the sample were cut at both ends, *simultaneously,* thus releasing the tension at both ends at the same time, there should be little possibility of water removal from the sample.

The amount of water removed from the branch segments when both ends are not cut simultaneously, should be directly proportional to the interval of time elapsing between the cutting of the two ends, directly proportional to the degree of tension existing in the segment, and inversely proportional to the resistance of the segment to the flow of water. The degree of tension developed in rapidly transpiring plants is dependent on several factors; namely, atmospheric conditions, light intensity, species, general health of the tree, height of the branch above the roots, and the available soil moisture. It may be said that, in general, environmental conditions conducive to rapid transpiration rates are also conducive to the development of high tensions. It should, however, also be noted that high tensions may occasionally be observed even when transpiration is slow.

Methods and results.—Tests were made to compare the moisture contents shown by similar adjacent samples from the same branch, one sample being cut at both ends simultaneously (cuts 1a and 1b of fig. 1), while the two adjacent samples were obtained by means of two single cuts. Each sample was about three inches long. For each branch the simultaneously cut sample was taken first, and was called the central sample. The cuts were made with two pairs of sharp pruning shears, one pair oper-

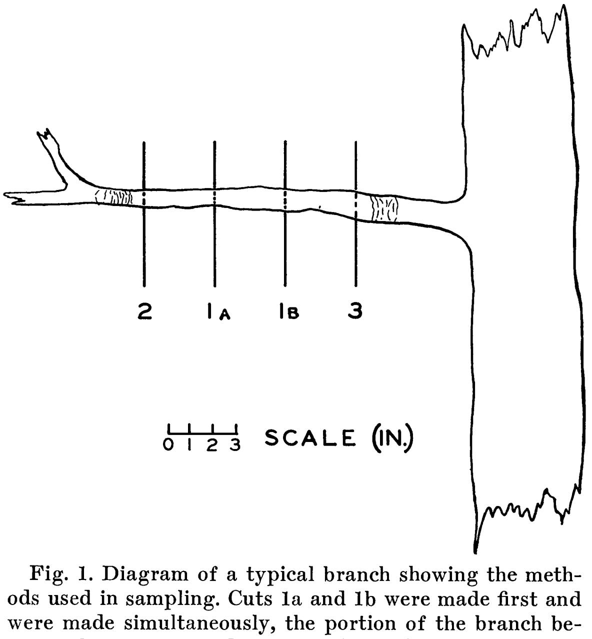


Fig. 1. Diagram of a typical branch showing the methods used in sampling. Cuts 1a and 1b were made first and were made simultaneously, the portion of the branch between them constituted the central sample. Cut 2 was then made and the portion of the branch between 1a and 2 constituted the distal sample. Cut 3 was made last and that portion of the branch between 1b and 3 constituted the proximal sample.

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TABLE 1. *Moisture contents of tree branches. All four cuts (cuts 1a, 1b, 2, and 3 of figure 1) were made within thirty seconds. Moisture content is expressed as per cent of the dry weight of the sample.*

| Species | | Rapid transpiration | | | Slow transpiration | | |
|---|---|---|---|---|---|---|---|
| | | Central | Distal | Proximal | Central | Distal | Proximal |
| Loblolly pine | 1 | 130.4 | 134.3 | 125.2 | 126.9 | 132.0 | 121.8 |
| | 2 | 114.9 | 115.0 | 111.4 | 120.3 | 118.7 | 117.9 |
| | 3 | 126.3 | 125.0 | 117.1 | 121.1 | 126.6 | 114.3 |
| | 4 | 133.6 | 129.3 | 125.8 | 176.7 | 148.1 | 125.2 |
| | 5 | 126.1 | 125.2 | 118.5 | 127.8 | 133.4 | 117.2 |
| | Mean | 126.26 | 125.76 | 119.60 | 134.56 | 131.76 | 119.28 |
| Shortleaf pine | 1 | 109.9 | 114.5 | 96.4 | 97.2 | 99.2 | 90.9 |
| | 2 | 106.3 | 109.4 | 96.5 | 78.4 | 76.7 | 74.0 |
| | 3 | 111.5 | 116.4 | 94.5 | 99.0 | 99.3 | 97.5 |
| | 4 | 124.4 | 123.5 | 112.2 | 71.6 | 70.8 | 68.9 |
| | 5 | 111.5 | 109.2 | 86.1 | 85.1 | 87.5 | 87.4 |
| | Mean | 112.72 | 114.60 | 97.14 | 86.26 | 86.7 | 83.74 |
| Yellow poplar | 1 | 128.7 | 112.4 | 117.1 | 114.3 | 109.9 | 99.6 |
| | 2 | 148.7 | 126.4 | 129.4 | 123.0 | 121.8 | 114.6 |
| | 3 | 124.6 | 118.6 | 116.5 | 122.2 | 124.6 | 111.2 |
| | 4 | 139.8 | 127.8 | 127.6 | 114.4 | 119.0 | 108.3 |
| | 5 | 133.6 | 115.3 | 114.7 | 112.0 | 113.9 | 99.3 |
| | Mean | 135.08 | 120.10 | 121.06 | 117.18 | 117.84 | 106.60 |
| Red gum | 1 | 115.9 | 102.6 | 96.9 | 110.1 | 110.7 | 106.0 |
| | 2 | 115.4 | 107.1 | 106.6 | 109.8 | 115.6 | 129.8 |
| | 3 | 144.7 | 122.2 | 126.1 | 88.4 | 108.3 | 94.2 |
| | 4 | 198.3 | 118.0 | 120.7 | 98.0 | 98.1 | 90.5 |
| | 5 | 117.7 | 106.3 | 107.2 | 101.7 | 102.5 | 96.2 |
| | Mean | 138.40 | 111.24 | 111.50 | 101.60 | 107.04 | 103.34 |

ated with each hand, and the process of cutting required less than one second. Then a single cut (cut 2 of fig. 1) was made to remove the second sample (called the distal sample) from the basal end of the already severed terminal portion of the branch, the remainder of the branch being discarded. Finally a second single cut (cut 3 of fig. 1) was made to remove the third sample (called the proximal sample) from the terminal end of that portion of the branch still attached to the tree. All three samples, which were of approximately the same length in each test, were from the same branch segment; thus all three represented the same age range of tissues and were nearly alike anatomically. All of the cuts were made within thirty seconds, and the time lapse between the simultaneous cuts (1a and 1b) and cut 2 was from ten to fifteen seconds, and the interval between cuts 2 and 3 was also from ten to fifteen seconds.

By means of this sampling technique five branches of each of the following four species were sampled: loblolly pine (*Pinus taeda* L.), shortleaf pine (*Pinus echinata* Mill.), yellow poplar (*Liriodendron tulipifera* L.), and red gum (*Liquidambar styraciflua* L.). All trees sampled were about ten to twelve feet high and were growing in open stands where the lower limbs were well exposed to light. The branches chosen for sampling were about four feet above the ground, and only one branch was sampled from any one tree. One series of twenty tests as described above was made between 11 a.m. and 1 p.m. on a hot, dry, sunny day in July when transpiration was presumably rapid for all trees, and a second series of twenty tests was made at a corresponding time on a cool, moist, cloudy day about two weeks later, when transpiration was presumably much slower than on the dry day.

As the samples were cut they were placed in closed weighing cans and taken into the laboratory where the wet weights were obtained. They were dried to constant weight in a forced draft oven at 80°C. and reweighed, the loss in weight being taken in each instance to represent the water content of the fresh sample. The value was expressed as a percentage of the corresponding dry weight. The resulting moisture content percentages are assembled in table 1. To segregate the effect of the method of cutting from the other sources of variation, an analysis of variance was made, the results of which are summarized in table 2.

The analysis of variance contains the information which is pertinent to this investigation. The question originally proposed was whether or not there is a difference in the moisture content between adjacent samples of the same branch which is directly ascribable to the method of sampling. The observed F for the method of cutting (the ratio of the mean square for the method of cutting to the mean square error) is 20.5, which is significant beyond the 0.001 level. This means that regardless of the other variables the method of cutting was responsible for real differences in the moisture content of the samples. The mean value for the central sample was 119.01, distal sample 114.38, and for the proximal sample 107.78. The value of *ts* (*t* times the standard

TABLE 2. *Analysis of variance of the data of table 1.*

| Source of variation | D F | Mean square | Observed F |
|---|---|---|---|
| Rate of transpiration | 1 | 3,942.24 | 12.05[a] |
| Species | 3 | 4,775.30 | 14.60[b] |
| Transpiration-species interaction | 3 | 1,019.84 | 3.12[c] |
| Branches of the same spcies | 32 | 327.04 | ... |
| Total for branches | 39 | 815.20 | ... |
| Method of cutting | 2 | 1,272.94 | 20.50[b] |
| Cutting-transpiration interaction | 2 | 351.84 | 5.67[a] |
| Cutting-species interaction | 6 | 78.77 | 1.27[d] |
| Cutting-transpiration-species interaction | 6 | 272.50 | 4.39[a] |
| Error | 64 | 62.08 | ... |
| Total | 119 | 345.57 | ... |

[a] Significant beyond the 0.01 level, *i.e.,* this result would be observed by chance less than once in 100 trials.
[b] Significant beyond the 0.001 level, *i.e.,* this result would be observed by chance less than once in 1,000 trials.
[c] Significant beyond the 0.05 level, *i.e.,* this result would be observed by chance less than once in 20 trials.
[d] Not significant at the 0.05 level.

deviation) appropriate for the comparison of means of forty samples is 3.52 at the 0.01 level, *i.e.,* differences which exceed this value are significant at the 0.01 level. The difference between the central and the distal sample means is 4.63, and that between the distal and the proximal means is 6.60. Thus the moisture content of the central sample is significantly greater than that of either the distal or the proximal sample. This constitutes conclusive evidence that, where a sample is taken for moisture content, the release of tension at one end at a time does not give a true picture of the moisture content of the sample. If the effects of the tension present in the xylem are removed by cutting both ends of the moisture sample at the same time, a better picture of the true distribution of water is obtained. Since the increment of time elapsing between cutting the central and distal samples was the same as that between cutting the distal and proximal samples, one would expect that the increments of moisture content would also be similar, but this is not the case. The difference between the moisture content of the distal and proximal samples is larger than would be expected, and it is possible that this is due to the very much greater volume of wood immediately adjacent to the proximal sample.

Other information is available from table 2 in addition to that bearing upon the effect of the method cutting. The rate of transpiration has a real effect upon the moisture contents. The rate of transpiration however is confounded with time, since the series of tests for rapid and for slow transpiration were made two weeks apart. During the period intervening between the rapid and slow transpiration tests the available soil moisture decreased. Thus a lesser amount of water was found in the tissues of all species except loblolly pine under conditions of slow transpiration than under conditions of rapid transpiration. The moisture contents of the species within one set of transpiration conditions were different, and the species had significantly different moisture contents under the two sets of transpiration conditions. One important item in table 2 is the observed F for the cutting-species interaction, 1.27. This is not significant and indicates that the effect of the method of cutting was the same in all species used. In other words this signifies that, as would be expected, the mechanism of water translocation through the branches is the same in all of the species used. The effect of the method of cutting on the moisture contents was significantly less under conditions of slow transpiration than under conditions of rapid transpiration.

In view of the data presented it is recommended that when branch segments are to be used for moisture samples under conditions such that the water in the xylem is under tension both ends of the sample be cut simultaneously. Possibly this precaution may prove unnecessary when samples are taken from deciduous trees during the dormant period, for it is probable that tensions developed in the xylem during that period would be rather small.

## SUMMARY

A method of sampling twigs and branches of trees for moisture content, under conditions such that tension exists in the xylem, is described. Samples from branches of four species of trees obtained by cutting both ends of the sample simultaneously had significantly higher moisture contents than adjacent samples from the same branch obtained by cutting one end fifteen to thirty seconds later than the other end. It is recommended that, when twig segments are to be used for moisture content samples under conditions such that tensions exist in the wood, both ends of the segment be cut simultaneously.

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