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# RELATIONSHIP OF NEEDLE SURFACE AREA TO NEEDLE VOLUME IN PONDEROSA PINE AND LODGEPOLE PINE.

by

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*ABSTRACT*

*The relationship of needle surface area to needle volume for ponderosa and lodgepole pine seedlings is presented.*

It is usually desirable to express rates of photosynthesis or transpiration on a common base such as leaf surface area. Direct measurement of leaf surface area in conifers is difficult; consequently, needle surface area often is estimated by relating it to a more easily measured characteristic such as weight or volume of needles.[1] [2] Clark[3] expressed rate of

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[1] D. R. Cable. Estimating surface area of ponderosa pine foliage in central Arizona. Forest Sci. 4: 45-49. 1958.

[2] T. T. Kozlowski and F. X. Schumacher. Estimation of stomated foliar surface area of pines. Plant Physiol. 18: 122-127. 1943.

[3] J. Clark. Photosynthesis and respiration in white spruce and balsam fir. Tech. Pub. 85, 72 pp. State Coll. Forest., Syracuse, N. Y. 1943.

photosynthesis on the basis of leaf volume, and a simple volumeter for estimating quantity of conifer foliage has been described by Ronco.[4/]

This paper shows the relationship between surface area and volume for individual needles of seedlings of ponderosa pine (*Pinus ponderosa* Laws.) and lodgepole pine (*Pinus contorta* Dougl.).

*Material and Methods*

Eighty needles that varied in length were taken from terminal and lateral shoots of potted 3-year-old seedlings growing in a greenhouse. Only one needle from a fascicle was taken. Needles were immersed in water overnight to assure maximum turgidity at the time of measurement.

In ponderosa pine, a fascicle consists of three needles which form a cylinder. In cross section, each needle has two flat radial faces and one curved outer face representing one-third of the circumference of a circle. The average width of the radial surface of each needle was determined by measuring the widths of both radial surfaces at three equally spaced locations along the length of the needle with a low-power binocular microscope.

In lodgepole pine, a fascicle consists of two needles which form a cylinder. Each needle has one flat diametrical face and one curved outer face representing one-half of the circumference of a circle. The average width of the diametrical surface was determined from measurements taken at three equally spaced locations along the needle. In both species, needle lengths were measured to a point a short distance from the needle tip to compensate for taper at the tip. Needle surface areas were calculated according to the equations:

$$S = 1/3\ Cl + r_1 l_1 + r_2 l_2$$
$$= 4.09\ rl \text{ (ponderosa pine)}$$

$$S = 1/2\ Cl + dl$$
$$= 2.57\ dl \text{ (lodgepole pine)}$$

where S, C, r, d, and l represent surface area ($mm.^2$), circumference,

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[4/] F. Ronco. Volumeter for estimating quantity of conifer foliage. Rocky Mountain Forest and Range Exp. Sta., USDA Forest Serv. Res. Note RM-133. 1969.

radius, diameter, and length, respectively. $R_1 l_1$ and $r_2 l_2$ refer to the dimensions of the two radial surfaces of a ponderosa pine needle.

After the measurement of needle dimensions, each needle was placed in a volumeter, similar to the one described by Clark (see footnote 3), and needle volume was determined by water displacement. Displacement was measured in a pipette graduated to 0.001 milliliter and interpolated to the nearest 0.0005 milliliter. A small amount of Aqua-Gro[5/] was added to facilitate wetting the needle and glass surfaces.

The accuracy of the volumeter was checked by measuring small stainless steel rods of known volume, and it was found that the volumeter underestimated true rod volumes by 0.5 to 1.3 percent, depending on the size of the rods. Values for needle volume were corrected accordingly. To minimize effects of temperature on volume changes, the reservoir of the volumeter was jacketed with a piece of Tygon tubing and all measurements were made in a laboratory at a constant temperature.

*Results and Discussion*

The relationship between needle surface area and needle volume is shown in Figure 1. A T-distribution test showed the regression coefficient

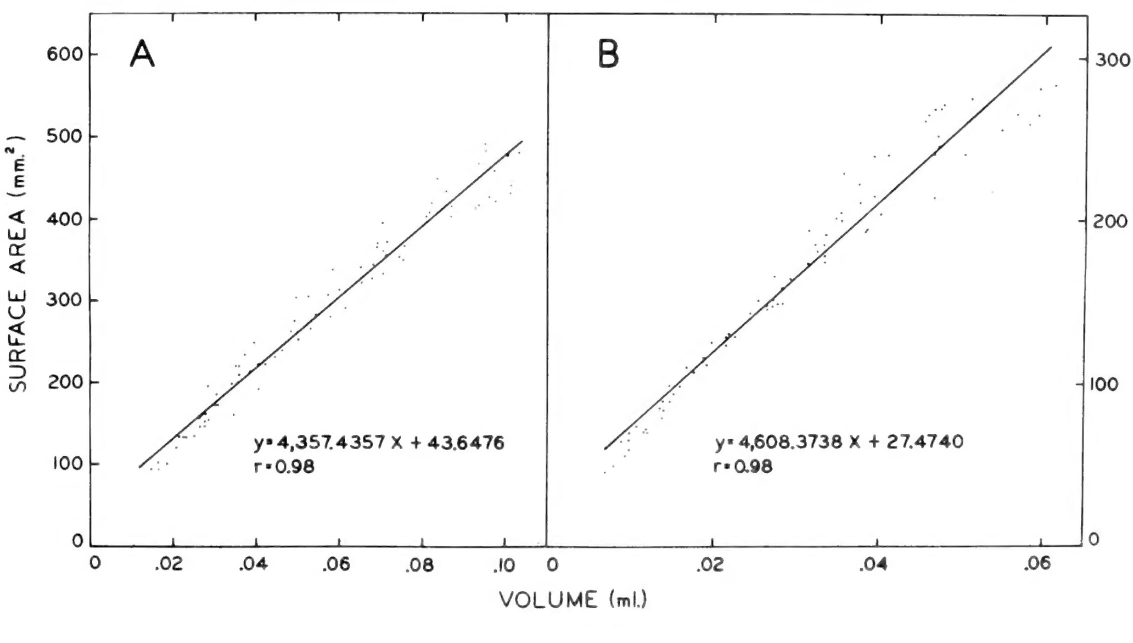


Figure 1.--*Relationship of needle surface area to needle volume for single needles of ponderosa pine (A) and lodgepole pine (B).*

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5/ Mention of products by name does not represent endorsement by the U.S. Department of Agriculture.

to be highly significant. There appears to be a change in slope of the curves below a needle volume of 0.03 milliliter in ponderosa pine and 0.015 milliliter in lodgepole pine, probably a result of a changing relationship of surface area to volume in very short needles.