Measuring Fibrous Roots with a Leaf Area Meter

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Highlight: *A commercial leaf area meter was tested for accuracy of measuring root area. The meter can accurately measure sample area with minimum length or width of at least 2 mm. All grass fibrous roots tested were smaller than 2 mm diameter and were not measured accurately by the meter.*

Absorption of water and salts by forage plants is dependent upon root surface area available for absorption. Estimates of root surface area can be obtained through dry weight measurement or through use of total length and average diameter estimates to calculate total surface area (Carlson, 1964; Schuurman and Goedewaagen, 1965). Root dry weight is relatively simple to obtain, but tells little about vertical penetration and lateral spread of the root system in the soil profile. Several workers have developed methods for estimating root system penetration and spread, through total root length estimates. Newman's (1966) method involves visual counting of root intersections with randomly placed straight lines drawn on a flat surface. Rowse and Phillips (1974) modified Newman's method by using a photoelectric counting device to record root/line intersections. Intersection counts were then converted to total length estimates by mathematical formulae.

Root surface area is a good indicator of absorption ability but is difficult to determine for large sample sizes (Schuurman and Goedewaagen, 1965; Troughton, 1957). Recently, commercial leaf area meters have proven useful in making rapid direct leaf area measurements (Ramos-Villanueva, 1974; Siewerdt, 1972). Since rapid, accurate measurements can be obtained, the feasibility of using a leaf area meter to measure total longitudinal cross sectional area of roots as an index of surface area was studied. Both root cross sectional area and root surface area are a function of length and width (diameter), thus it was felt that total cross sectional area would be an index to total root surface area. Initial attempts to determine the root surface area of four grass species gave very erratic results, apparently due to the small root diameters. The following study was set up with the objective of determining the smallest diameter root which could be measured accurately with the leaf area meter, and to determine the limitations of this particular model for estimating root surface area.

Materials and Methods

A commercial Hayashi Denko AAM-5[1] area meter was used in all measurements. This meter uses a celluloid conveyor belt to carry samples between a light source and a photoelectric cell (Fig. 1). Light intercepted by the sample is measured by the photoelectric cell, converted to area measurement (in mm^2), and the results displayed on a digital console. A metal test plate of known area is provided by the manufacturer to calibrate the meter.

Roots were simulated with art construction paper 0.5, 1, 2, 3, 4, 5, and 10 mm wide and 229 mm long. After the minimum acceptable width was determined, samples of that width were trimmed in length to determine the smallest total area accurately measured by the meter. Minimum width was measured with older (scratched from repeated use) conveyor belts, and then with new belts. Minimum area was determined with new belts only. The leaf area meter was calibrated prior to each set of measurements using the metal test plate. All readings were repeated five times. Correlation coefficients were determined for known vs meter-measured sample areas. After the minimum acceptable sample width was determined, the percentage of roots smaller than that

[1] Mention of trademark does not necessarily imply endorsement of propriety products by the Texas Agricultural Experiment Station over similar products for the same purpose.

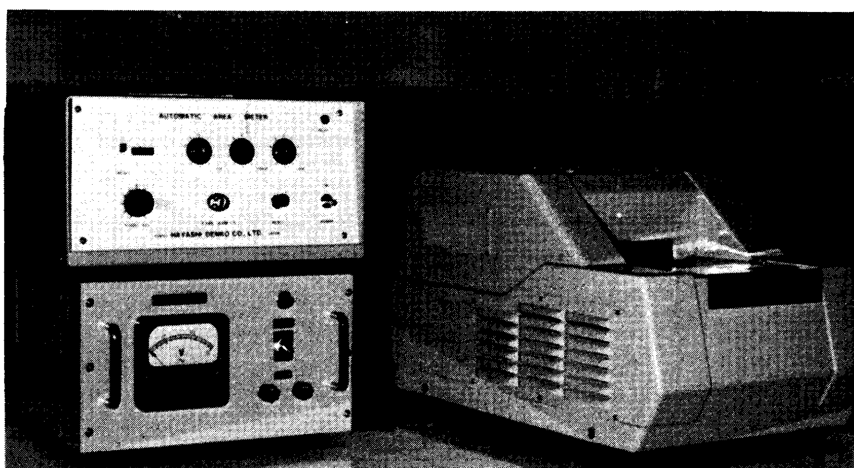

Fig. 1. *Hayashi Denko AAM-5 area meter. Plant samples are fed into slot on conveyor belt console (*right*) and area measurement is read directly from digital readout console (*top left*). Power supply is at lower left.*

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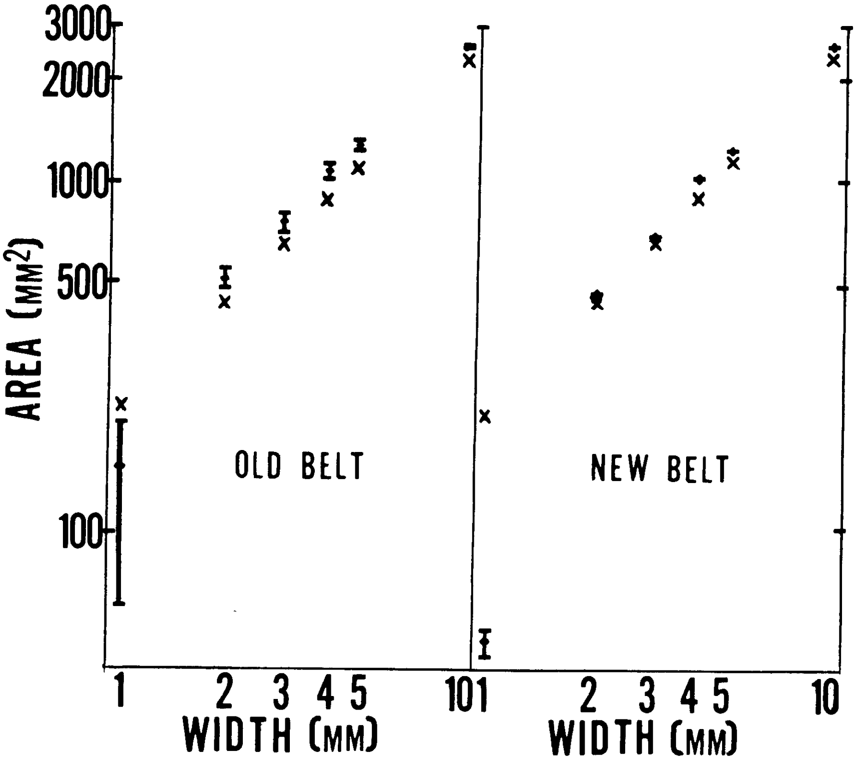

Fig. 2. *Machine reading versus actual sample area for each width tested. Actual sample areas are shown (x). Machine reading mean value (dot) and range of the readings (vertical bar) are presented for each width. Five readings were taken at each sample width. Area measurements are width multiplied by 229 mm standard sample length.*

minimum diameter was determined for the four grass species used in the initial measurement attempts.

Results and Discussion

Meter readings with new and old belts were closely correlated with actual measurements to a minimum sample width of 2 mm (Fig. 2). Readings at 1 mm width were erratic and at 0.5 mm width a zero reading was obtained utilizing the old belts. Readings with new belts were much more precise than those with old belts.

Area readings were accurate to a minimum of 5 mm^2 using the 2 mm width and new belts. Correlation coefficients for width readings with both old and new belts were 0.99, indicating extreme accuracy within the sample sizes measured. Area readings correlated perfectly, indicating extremely accurate measurements by the leaf area meter as long as the width was 2 mm or greater. However, all roots of the four grasses tested were smaller than 2 mm width (diameter). Thus, the initial erratic root measurements on the four grass species were apparently due to the root diameters being smaller than 2 mm.

Since the minimum acceptable width for measurement is approximately 2 mm (not specified in instruction booklet by manufacturer), this model leaf area meter is not suitable for direct measurement of fibrous root systems. Manufacturer's recommendation is to use photo enlargements of small roots in order to obtain accurate results. Presumably this means to cut out the individual roots in the photo enlargements and pass these cutouts through the leaf area meter. This procedure would be applicable only to very small root systems though, due to the great amount of time that would be required to cutout large root systems for measurement. The leaf area meter should be suitable for rapid direct total longitudinal cross sectional area measurements of large roots, and surface areas of small leaves such as those of buffalograss (*Buchloe dactyloides*), as long as minimum sample length and width is at least 2 mm. Researchers should check newer models for improved capabilities in direct measurement of small fibrous root systems.

Literature Cited

Carlson, C. W. 1964. Problems and techniques in studying plant root systems. Proc. Ninth Int. Grassland Cong. 9:1491-1493.

Newman, E. I. 1966. A method of estimating the total length of root in a sample. J. Applied Ecol. 3:139-145.

Ramos-Villanueva, M. 1974. Growth and nutritive quality of coastal bermudagrass as influenced by nitrogen fertilization, defoliation and water management. MS Thesis, Agron. Dep., Texas A&M Univ.

Rowse, H. R., and D. A. Phillips. 1974. An instrument for estimating the total length of root in a sample. J. Applied Ecol. 11:309-314.

Schuurman, J. J., and M. A. J. Goedewaagen. 1965. Methods for the examination of root systems and roots. Wageningen. 86 p.

Siewerdt, L. 1972. Management of 'Siratro' and 'Miles lotonis' in association with kleingrass. MS Thesis, Agron. Dep., Texas A&M Univ.

Troughton, A. 1957. The underground organs of herbage grasses. Bull. No. 44. Commonwealth Bureau of Pastures and Field Crops, Hurley, Berkshire. 163 p.