

8-12-1949

Quantitative Study of Root Systems in Different Soil Types

J. E. Weaver

University of Nebraska - Lincoln

R. W. Darland

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Weaver, J. E. and Darland, R. W., "Quantitative Study of Root Systems in Different Soil Types" (1949). *Agronomy & Horticulture -- Faculty Publications*. 498.

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line were to be found in the zone 0.7-1.0. Tryptophane, methionine, cystine, and phenylalanine could not be identified by this technique, since they are oxidized during the partitioning process.

For our purposes the lysine band, because of its relative consistency, proved most useful. The band spread of the copper lysine salt is roughly proportional to the concentration in the range 30-60 γ of lysine. With protein hydrolyzates containing initially 0.5 mg N/cc it was found that zein gave negative tests; wheat gluten gave faintly positive tests; and casein, gelatin, lactalbumin, human hemoglobin, and fibrin gave bands which approximated roughly the lysine content of the preparations.

Fivefold concentrates of urines of adult or infants on normal diets showed the lysine concentration to be greater for the infant than for the adult. When a wheat gluten diet supplemented to contain 4% L-lysine was fed to infants, the lysine output was similar to that of an evaporated milk diet. When the infants were fed wheat gluten diet without the lysine supplement, the urine lysine level fell below the sensitivity of the test. Supplementation of this diet with 6% D-lysine caused a tremendous increase in the lysine output, which became normal on changing to 6% L-lysine. On the basis of this observation and the poor N-retention and weight changes manifested by infants maintained on the D-lysine-supplemented wheat gluten diet it would appear that D-lysine is not utilized for growth by the infant.

Blood filtrates could not be manipulated satisfactorily to give positive tests by this procedure.

Within limitations this method is a useful one, but it cannot be expected to yield better than semiquantitative results. Other metal salts of the amino acids—namely, nickel, silver, chromium, mercury, lead, and barium—are being studied to determine their chromatographic characteristics.

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Quantitative Study of Root Systems in Different Soil Types

J. E. Weaver and R. W. Darland

Department of Botany, University of Nebraska, Lincoln

Study of soil-root relations of various crop plants and range grasses has lagged far behind the pressing need for an understanding of these relationships. Little progress in devising new methods for such study, at least methods that have been widely used in the field, has been made since the extensive researches by the direct method, using trench and hand pick, employed by Weaver (1, 2) during the period 1919 to 1926. This lack of a quantitative approach to comparative root studies in various soil types has undoubtedly been a chief reason for the dearth of more definite information on this important subject.

A new method has recently been devised by which a complete sample of an entire root system from soil sur-

face to maximum depth of penetration may be taken, separated from the soil without injury to the root or displacement of individual roots from their natural position, and examined in the laboratory in relation to the various horizons of the soil profile. The method, applied to range grasses, consists in obtaining monoliths of soil 12 in. wide and 3 in. thick to a depth, varying with root extent, of 3-6 ft.

A trench about 3 ft wide and 4-5 ft long is dug in a site where there is normal development of vegetation. The depth is usually 4-6 ft. Beneath the particular sample of grass, previously selected and left undisturbed in the side wall, the wall of the trench is made smooth and vertical, as shown by a plumb line. A long shallow wooden box, 12 in. wide and 3 in. deep (inside dimensions), without a top and lacking one end, is employed. It is placed on end, with the closed end downward. The open top is placed against the vertical trench wall, the upper end of the box just reaching the soil surface. An impression of the sides and lower end of the box is made on the vertical wall of the trench by tapping the bottom of the box vigorously with a 4-lb sledge. The box is then removed and the soil column marked out with butchers' knives having rigid blades. The soil on the sides and below these marks is removed by means of knives and spades until the monolith protrudes from the trench wall, its sides and bottom extending outward at least 3 in. The box is then fitted tightly over the monolith and the bottom and lower end of the box are braced to hold the soil column in place. Finally, the soil on the inner, attached face of the monolith is cut away by working inward with knives and spades from each side. The soil is not cut close to the top of the box, but a V-shaped ridge of soil is left protruding throughout its length. This is a part of the sample when the braces are removed and the monolith is lifted out of the trench. The entire monolith is transported to the laboratory, where a description of the profile as regards soil texture, structure, consistence, pH, etc. is made. Only then is the monolith reduced to exactly 3 in. in thickness.

The soil is removed from the box by a process of repeated soaking, often for several days, and gentle washing, mostly under water, even when it is extremely compact or contains a claypan. A flaring rose nozzle attached to a garden hose is employed. During this process one may study the intimate relations of soil and roots. Roots are unharmed and in their natural position in the water after the soil has been washed away.

The root system is transferred to a large smooth painted board. The board is kept wet and tilted while the roots are finally washed free of any remaining soil. Excess water is then removed by large blotters and the damp root system is transferred to a mounting board covered with cloth of black felt. This is done by placing the mounting board, face downward, over the root system, holding the two boards tightly together, and inverting them. The painted board is then removed. The root system is lighted for photographing by electroflash units. It may then be dried and preserved indefinitely or cut into sections according to depth in feet or according to

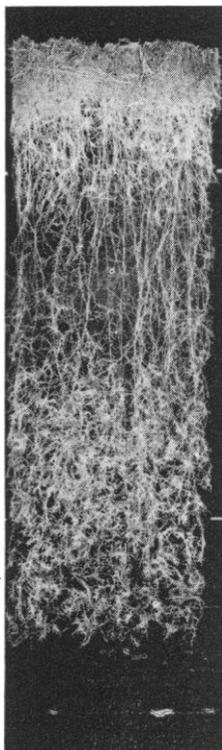


FIG. 1. Portion of a root system of western wheat grass (*Agropyron smithii* Rydb.) 12 in. wide and 36 in. deep. The bottoms of the A and B horizons are marked by white lines. Only a small portion of the roots in the C horizon is shown.

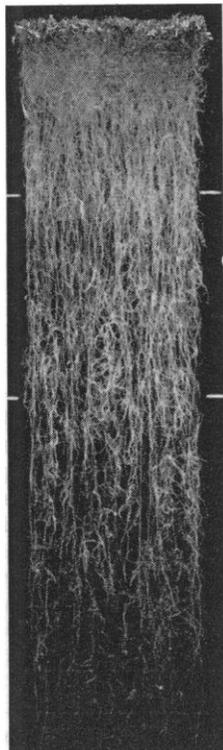


FIG. 2. Upper 4 ft of roots of buffalo grass *Buchloë dactyloides* (Nutt.) Engelm. Upper lines mark the depth of a 12-in. fill which gradually buried the former topsoil (A_{1-1} horizon). 14 in. thick. Note excellent root development in these layers.

depth of the soil horizons it occupied. The roots are then oven-dried and weighed.

The root system in Fig. 1 was taken from Butler silt loam soil 28 in. deep, overlying deep, friable, silty clay loam parent material. The A horizon, which is only 7.5 in. thick, contained 67% of the roots by weight. Roots were poorly branched in all but the lower part of the claypan or B horizon. Most of the branching occurred in the C horizon of less compacted, friable silty clay loam. Roots in the 13 in. below the point of heavy branching weighed 36% more than the 13 in. of poorly branched roots above. The root system in Fig. 2 was taken from Wabash silt loam in a valley between two loess hills. Although the grass is normally only 4-5-in. tall, the roots are 5-6 ft deep.

Descriptions have been made of the profiles of 16 soil types, from which 11 species of grasses were taken in a total of 33 monoliths in 1948.¹ The depth, density, and weight-distribution of roots of the same species in dif-

ferent soil types and of different species in the same soil type have been ascertained. Quantitative data on root distribution in the several soil horizons have also been obtained. The effect of buried profiles on root habit has been examined, as have modifications resulting from the loss of one or more soil horizons by erosion. A detailed account of the work is in press.

References

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A Simple Micromanipulator

Gunnar Nygaard

Lektor at Ordrup Gymnasium, Charlottenlund, Denmark

For the isolation of one microscopic cell a fine capillary pipette is often used, the point of which is inserted into the drop of fluid containing the organisms; under microscopic control a single cell can then be sucked into the capillary pipette. The difficulty of this operation consists in keeping the point of the pipette motionless, at a magnification of, say, 100 times, in front of the organism, which in many cases has a size of only 10-25 μ .

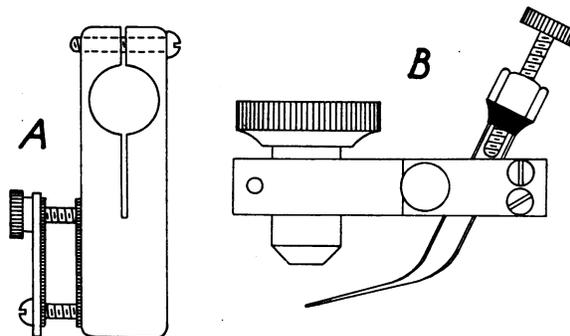


FIG. 1. A. Micromanipulator top view without the capillary pipette. B. Micromanipulator with the capillary pipette, side view, mounted on the objective of the microscope. Three-fourths natural size.

The device described here is one whereby the pipette can be fastened to the objective of the microscope. By means of the mechanical stage of the microscope, the organism can then be moved to the mouth of the fastened capillary pipette and sucked up.

As shown in Fig. 1, the apparatus may consist of a block of metal 55 mm long, 15 mm broad, and 10 mm high, or to avoid scratches on the side walls of the objective, of a corresponding piece of ebonite or plastic used for insulating purposes by the electrical industry. In one end, there is a vertical hole for the objective, and a deep incision so that the walls of the hole can be fastened around the objective by means of a threaded bolt. On the side wall of the other end is placed a retaining plate, so that the capillary pipette can be pressed against one vertical wall of the block by means of three screws. Small pieces of felt or thin plates of

¹ Profile descriptions were made by Mr. James Thorp, Principal Soil Correlator, Great Plains States Division of Soil Survey, U. S. Dept. of Agriculture.