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Roots

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Introduction

When I found a way of giving my students a better view of what goes on underground, they started asking better questions, and they found better ways of answering those questions.

That was the most exciting aspect of some work I was doing for the Agricultural Research Service (ARS). My assignment was to find ways of using, in the classroom, some of the techniques developed by Dr. Howard Taylor and his associates at Iowa State University involving investigations into root growth.

Rootview

I was just under way with the assignment when the entire Science Study Aid project of the ARS folded for lack of appropriations. By that time, however, I had designed a growth chamber that I was using for observations of root growth at Ames High School. After the ARS bowed out, I took my plans to Olson Manufacturing Company with the hope that their designers could solve some of the problems that had thwarted my progress. Oddly, I was then unaware that the Olson firm had helped construct the 53-foot acrylic-lined tunnel that reveals root growth in some of the ARS studies.

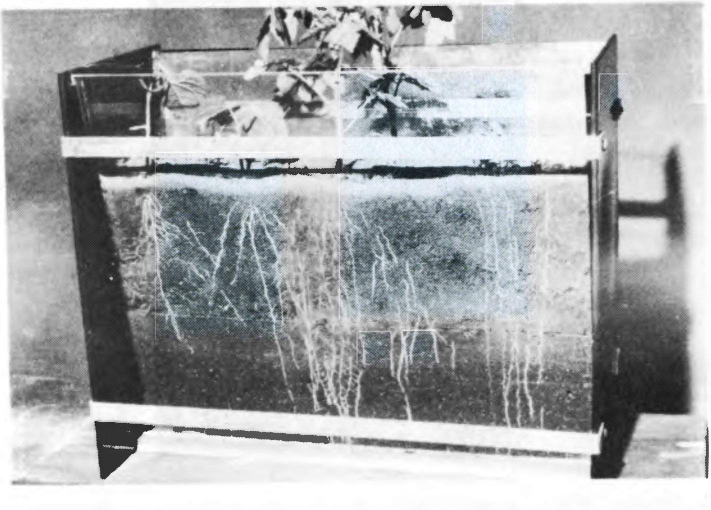

Fig. 1. The walls of *Rootview* slope inward causing positively geotropic roots to grow against the transparent surface making observations of root development easier.

Eventually Olson Manufacturing of Ames not only solved the design problems — they offered to produce the *Rootview* for distribution by science supply firms. *Rootview* has high-impact acrylic walls that slope inward. Since roots react positively to gravity, they tend to grow against the walls (Fig. 1). Sloping walls are better than vertical walls since you are able to see more of the underground life of plants — of earthworms and soil insects, too.

Water

What kinds of questions can the students investigate when they have a better view of root development? Well, there is the question of why drain pipes become clogged by tree roots. Is it because the roots are "*searching for water*"? No single test is likely to answer this question for critical students. The plan that worked best for us was to arrange watering pipes near the ends of the *Rootview,* with the lower end of the pipes sealed. At one end of the chamber, on both sides, small holes allowed water to seep out along the sides of the pipes.

If your botany professors were like mine, you already know that roots don't *search* for water. They don't grope along looking for it. They simply grow faster where water *is* than where it isn't.

Incidentally, we found a good alternative to making a photographic record of the response of roots in various demonstrations. After taping a sheet of transparent plastic over the acrylic wall, we traced over the roots with a felt-tipped pen (Fig. 2). We could then project the copy on a screen so the entire class could see it at one time.

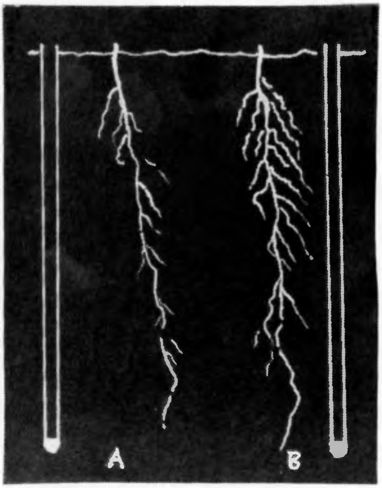

Fig. 2. Tracings of root growth are made easily on transparent plastic and used for overhead projection. Water in tube A was not available to a pea seedling; they grew toward tube B, perforated so water could seep out.

Compaction

Another question concerns the effect of compacted soil on plant growth. Compaction is a problem not only in field crops, where heavy machinery repeatedly compresses the soil, but also in parks and lawns where countless heavy feet do the same thing (Fig. 3). By compressing the soil, compaction reduces the amount of oxygen available to roots. We found a way of demonstrating this in the lab, using two samples of soil from the same source. We accomplished the compaction by pounding moist soil with a mallet.

Fig. 3. Oak wilt? No, it's a root problem caused by heavy human traffic in an Ames park. Compaction reduces the underground oxygen supply.

From this observation a spin-off question arose: do earthworms reduce the effects of compaction? Fortunately we had some worms on hand and we were able to answer the question by *doing*. Of course, students could have found the answer in print. Earthworms and other burrowing animals really do help aerate the soil. But there is more learning involved in planning a controlled experiment and *discovering* the answer.

Flooding

Flooding is the most dramatic way that roots are deirived of sufficient oxygen. When a corn field is flooded, the plants may die for lack of water. This sounds contradictory; but if roots deteriorate because they lack oxygen for respiration, they may fail to provide enough water to keep the stem and leaves alive. Plant species differ a good deal in their tolerance to flooding. Rice, of course, is well adapted to a high water table. If your students wonder how various species compare in this way, they can see for themselves. The *Rootview* provides normal drainage at the bottom, but it can be water-proofed with aluminum foil, raising the water table to mimic a natural flood.

Root Adaptations

One of the most satisfying questions that has come up in my classes came out of a simple demonstration of various patterns of root growth. When students learn that there are two basic root types, tap and fibrous, they are likely to conclude that if they remember examples of these two types, then they've *got it.* Actually there is great variation among tap roots and among fibrous roots. *Why?*

Seeing some of this variation makes it easier to approach this important question. A part of the answer is that conditions in the soil differ. Roots are adapted for different environments. Yet when you find two plants growing side by side in a prairie, or in a forest, with quite different root systems, it is apparent that conditions of the environment are only a part of the answer.

I believe that a more important part of the answer is that the plants of a prairie, a forest or any other habitat are living on a crowded planet. They compete with each other. If they were all alike, the competition would be more severe. Because they have evolved different growth forms, they make better use of the available water and minerals in different circumstances.

This principle applies equally well in the protist and animal kingdoms. Variation in design has enabled life to exploit the resources of the earth more efficiently.

Motivation

For motivation, you may have to pose some questions yourself. Grade-conscious students, trained to please the teacher, gradually lose a lot of their natural curiosity. But there is enough left that you can encourage them to *inquire.* Fasten a small block of wood on the inner surface of the acrylic wall below a point where you plant a radish seed. Silicone glue works well. You'll find the students watching to see what the roots will do when they reach the blockade. That's a start, then one question leads to another.*

*A pamphlet that accompanies the growth chamber contains more detailed guidelines for investigating root growth.

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