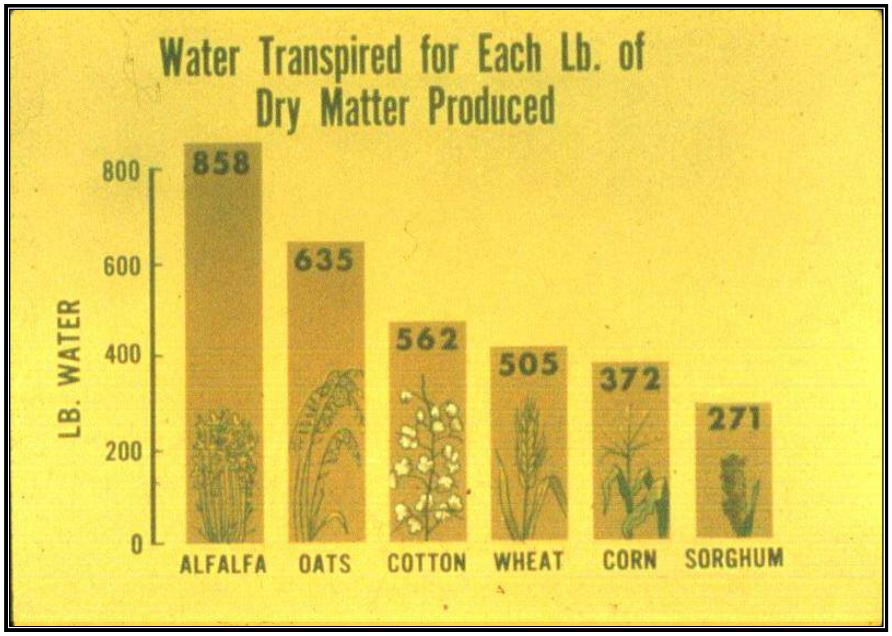
Roots, Rooting and Water

- Building on Healthy Soil
- A Healthy Root System
- For a Healthy High Producing Plant
- Adding more carbon to soil
- For a Healthier Soil
- Which produces more fertility
- More productive, healthier plants

This following set of slides is devoted to roots and root systems and the intricate relationship to soil-water management. A healthy root system and a healthy high producing plant that develops from that root system is the key to growing topsoil.

We will see some plants that added more than the usual amount of carbon to soil to make a healthier soil which in turn produces more natural fertility. All this leads to better productivity with healthier plants with more net profit.

We will see why increasing soil carbon does not mean that we should stop tilling our soils.



A good starting point in talking about root systems and plants is the amount of water that plants require to produce a pound of dry matter. Of course for most plants the majority of the water they consume is supplied through the root system.

As you can see this chart reveals that broadleaf plants like alfalfa consume relatively huge quantities of water to produce 1 pound of dry matter. The grass family plants such as corn and sorghum take but a fraction of the amount of water to produce 1 pound of dry matter.

Meeting these kinds of water requirements means the soil must effectively store that water when it arrives. Secondly, it must be able to resupply that water to the plant during the period of insufficient precipitation for normal growth. This means that soil structure must provide for rapid movement of water and uniform capillary action returning the water to the plant root mass.

Obviously the next major consideration would be producing a root mass which also reaches deep into the stored water reserves of the soil. An example of how poorly most crop production systems perform is to do a trial calculation. If one assumed an annual rainfall of a mere 400 mm per year and produced corn for silage, 100% efficiency of the water supply should produce 4.73 metric tons of 35% dry matter of feed per hectare. Now that's not a lot of corn silage but that's very little rainfall. Most farmers in areas with that rainfall amount don't even attempt to grow corn for silage without irrigation.

When there's too much water…

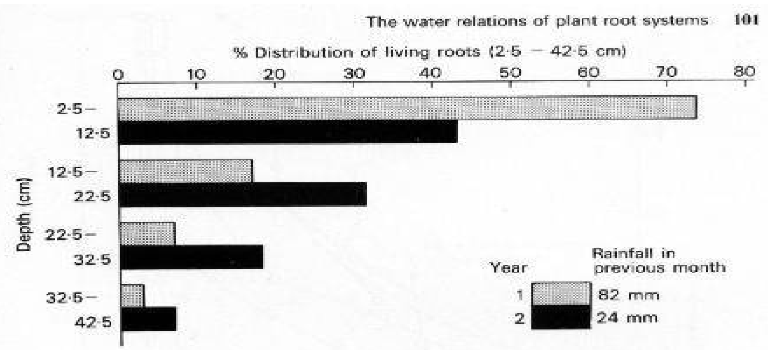


FIG. 5.5 Contrasting distribution of living roots of spring barley grown in the same field in successive years: measurements two months after planting. In Year 2 drier conditions in the surface soil much reduced the fraction of roots in that zone.

The relationship between root density and depth was exponential in Year 1 and linear in Year 2. The percentage of the total variation accounted for on the two bases was: Exponential relationship – year 1: 98 (13), year 2: 74 (25). Linear relationship – year 1: 78 (55), year 2: 99 (7). The figures in brackets show the maximum percentage difference between the calculated values and those observed for individual horizons. (Derived from Ellis et al., 1977.)

Taken from Plant Root Systems by R. Scott Russell, McGraw Hill (UK)

Most agricultural areas however, don't experience a nice irrigation schedule when it comes to gathering water or supplying water to growing crops. This report of the distribution of root masses under spring planted barley is very illustrative of the problem.

The chart reveals the dry matter root mass in various depths of soil grown in two different years. In the first year the amount of rainfall was nearly 3 ½ times the amount in the second year. And you can see the exponential increase in the amount of root mass that developed in the top 2 ½ to 12.5 cm of soil.

In contrast nearly 45% compared to almost 75% of the root mass developed in the top 12 ½ cm when rainfall was more normal. The tragedy of this poor distribution of roots on a wet year is that when it stops raining there are very few roots to relate to deeper stored moisture reserves.

The explanation for this poor distribution of root systems is usually oversimplified. As we'll see in the next study, there are products created in an anaerobic soil which persist well beyond the time when soil air is limited.

We won't even go into the cost of denitrification of soil nitrogen resources that probably transpired when rainfall exceeded the soil's capacity to transport the water quickly downward and restore air to the top 12 ½ cm.

Watch the Arrows

210 Plant root systems

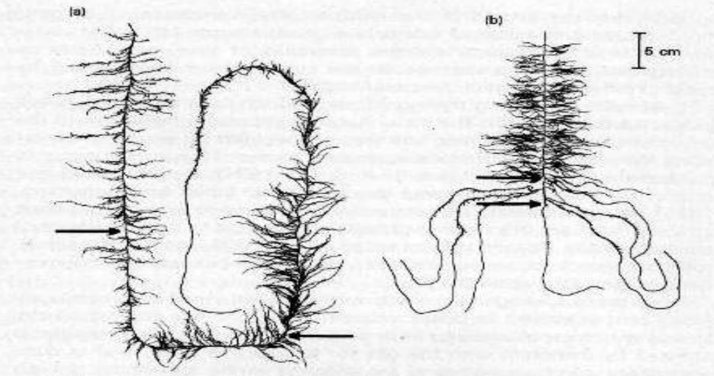


***FIG. 9.5** Seminal axes of 35-day-old seedling of barley* **(Horedum vulgare)** *grown in solution culture.* **(a)** *Control.* **(b)** *The root system was exposed to 10 ppm ethylene in air for thirteen days (9–22 days after germination), and then transferred to an ethylene-free environment for thirteen days before sampling. The arrows indicate the position of the apex at the beginning and end of treatment with ethylene (Crossett and Campbell, 1975).*

Taken from Plant Root Systems by R. Scott Russell, McGraw Hill (UK) 1977

Let's look at barley again in an experiment done in Britain. The plant on the left was the control. The plant on the right was subjected to a 10 ppm concentration of ethylene gas for a period of 13 days beginning nine days after germination.

The second arrow indicates the conclusion of the treatment time period on both plants. It's fairly obvious that the root mass development characteristics of the plant receiving the ethylene treatment were greatly altered compared to the control. This type of lateral growth is the type of thing which would constitute a large percentage of total root mass being developed near the top of the plow layer in a long-term high moisture situation. It's in this anaerobic environment where bacteria generate ethylene gas.

The effects last well beyond the period of time when the water has disappeared from sight.

What is possible????

- Grown in zero compacted soil, this plant yielded over 400 bu./ac. equivalent-no applied plant food.
- Main roots to bottom in less than 72 hours.
- The clock is always running on rooting.

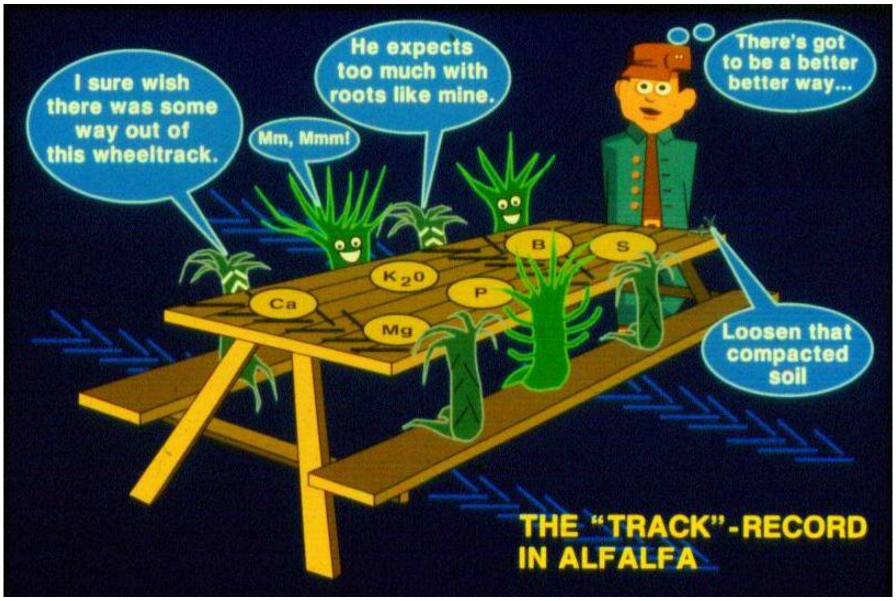
We're looking here at a corn plant root mass grown in zero compacted, unweathered topsoil which is about two meters deep. Fertility supplied to this plant included no commercial fertilizer.

What is most startling is to realize that the primary root mass developed to a depth of 2 m within 72 hours after germination. Each subsequent root which developed during the plant's life grew no more than 72 hours before the growing tip matured and additional lengthening was terminated. Any additional rooting activity after pollination was not observable.

This work at Auburn University and other work at universities around the world has shown conclusively that the ear embryo formation which determines the row count and the primary yield setting activity, occurs 40 days after germination, at the conclusion of the primary root mass development.

Now consider what we're looking at here and compare it to what we've been talking about with soils that fail to handle excessive amounts of water early in the growing season. Then also consider the fact that the impact of the production of a compound like ethylene exists well past the date when the ethylene was being produced in the soil.

Perhaps now my preoccupation with tillage and redefining it as normalizing water transport and air exchange is so relevant to our discussion of root systems and root system development.

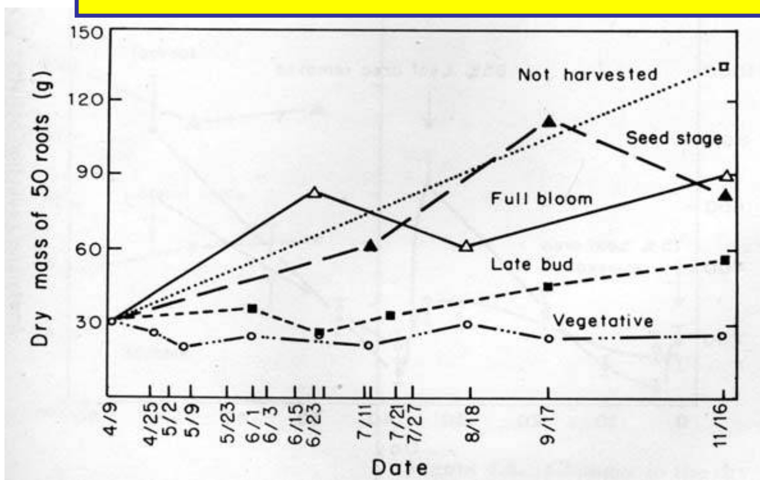


Shifting gears slightly let's take a look at rooting habits of perennials like alfalfa. Although this picture emphasizes compaction forces and their capacity to limit root development on young seedling alfalfa plants, the overall soil condition which develops over time is not unlike what happens to an annual crop like corn. The production of compounds like ethylene have a deterring effect on the root activity on perennials as well.

To the point of this slide, I did several field studies many years ago to determine where alfalfa plant mortality takes place in the field. The astounding finding was that 50% of the plants that germinated in the planter wheel track were dead in less than three years. In some soils the wheel track was observable for the total lack of alfalfa plants left after three years.

To the extent to which systematic use of tillage is used to facilitate air and water exchange and systematically remove compaction, it is possible to maintain vigor and optimal soil environments for an indefinite life expectancy of a perennial crop.

What is the best time to till Alfalfa?



ALFALFA: Read my root system Dry Matter

Although certain advantages will accrue from performing tillage in perennials at any time, there are times which are especially advantageous if the operation coincides with the regeneration of root mass.This work was done at the University of Wisconsin. After studying the chart one can quickly discover that the process of blooming is critical to the development of dry matter in root mass. If the goal of management is to, at the very least, replace the root mass on an annual basis, it is apparent that the plant must achieve a late bud stage at least once during the growing season.

Obviously if the soil has been mechanically loosened or tilled, optimal water movement and air exchange will create optimum biological support for root growth. Secondly, the physical action of the Free-Till™ machine will produce bulk density reductions in the soil to create greater root system development.

The normal recommendation for performing this operation is at or near the end of the growing season. At this time of the growing season, allowing the plant to stand longer before harvest, say until bud late bud stage or even flowering is achieved has minimal impact on the relative feed value of the crop.

First year experience in Clay Loam Soil-Convoy, OH

Many researchers and farmers look for a change in tillage to create a dramatic change in the first crop season. The operation of this machine and what it is affecting rarely allows the luxury of a short-term response.

However it is normally possible to make observations to verify that the root system development under the crop has indeed been altered. The heavy clay soils in which this plant was grown normally produced a root mass which rarely saw a root system that exceeded 20 cm in length. These measured well over 45 cm in length. The clusters of roots also indicated clearly the location of the tine penetration.

Todd Mason, Cape Vincent, NY USA 2007 22nd Year

Todd was barely out of high school when he first ran the original introductory tool which mimicked the New Zealand original. This picture of Todd and the typical corn plant grown on his farm in 2007 celebrated 22 years of continuous singular use of the original NZ tine design. An extensive interview and examination of the soil which has developed on the farm is available on DVD.

When Todd and I worked to remove this plant , I was prying with a long shovel handle and Todd was pulling with everything he had. The long root you see broke off at 1 m in length. In earlier efforts to establish the rooting depth in these extremely heavy soils, roots were observed under corn crops reaching depths of more than 2.5 m.

In 1999 precipitation on this farm ended for the growing season on June 9th. The next precipitation occurred on September 12 after harvesting nearly 7.37 metric tons per hectare of 35% dry matter corn silage. The neighboring farm average for that same year was exactly half. The Masons harvested alfalfa which averaged right on the annual average for the farm.

The soils on this farm are 45% Clay, 45% silt and less than 5% sand. Improving drainage by internally using perforated tile is impractical. Yet the soils transport water so rapidly they perform more like the sand. You can see an extensive **soil health audit** report by Cornell University on these unique soils.

“Secret” =Where the roots grow

The soils here on the Mason Farm have never been mixed more than 3 cm deep in 22 years. They have always been tilled 20 cm deep at least twice per year. The routine annual application of liquid dairy cattle is surface applied. The result is a biologically active 20 cm deep root zone.

This picture was taken well over one month following pollination of the corn crop. The color of these roots is indicative of the health in the soil environment which has nurtured the root system of this plant throughout the growing season. Plant diseases are virtually unheard of on this farm.

As you examine the picture of this corn root ball, notice the zones of concentrated root mass. Part of the success of this tillage system depends on the development of new zones of preferred rooting activity. This extremely random pattern of root growth has created uniform carbon deposits from rapidly degraded non-lignified root systems for a quarter of a century. And for that reason the ratings for potentially mineralizable nitrogen and active carbon are virtually unheard of in agricultural soils.

After 20 years the only soil amendments brought onto this farm are calcium carbonate and boron fertilizer. The Masons still practice chemical weed control and make no compost applications to achieve the results they have experienced.

35,000 in 20" rows; Manure and Prozyme Yielding 12.8 tonnes/hectare non-irrigated

This corn planted on 50 cm wide rows, not irrigated, is the product of the same type of tillage management that has characterized the Mason Farm. These results are being achieved after just three years.

The success these people are seeing is a result of patient, consistent attention to annual operation of the Free-Till™ machine. Monitoring changes in soil chemistry in the surface 5 to 6 cm is essential to creating intense biological activity. This activity will eventually permeate the entire root zone.

Please take advantage of our website at **www.freetill.cn.com**. It will contain important information to guide you in your faithful operation of the Free Till™ machine. We are prepared to work with helping professionals and farmers who desire to know more.

Truly a new day is emerging in land stewardship. The strength of soil it has been said is the strength of a nation. We believe that it is possible to rebuild that foundation in any soil, anywhere. Watching what faithful men have achieved in 25 years has proven the point.

In the U.S. we call it the Curse-Buster machine: **www.soilcursebuster.com**