Colorado Master Gardener

G A R D E N I N G S E R I E S

Colorado
MASTER GARDENER

Plant Structures: Roots

no. 7.703

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Line drawings by S. Johnson.

Outline . . .

Thought questions:

- Last summer during a home remodeling project we raised the soil level 12 inches in the yard. This summer my trees look stressed with small yellowish leaves. I don't see any insects. Could the problems be related to the soil change? My contractor assured us that trees are deep rooted.
- Since you can't see the root system, what would be the symptoms of root and soil related problems?

The roots are the beginning of the vascular system pipeline that moves water and minerals from the soil up to the leaves and fruits. Roots make up about one-fourth to one-third of the total dry weight of a plant. The total length of root tissues in a single rye plant is around 380 miles!

To function, roots must have adequate levels of oxygen from the soil. Soil compaction or waterlogged soil situations reduce soil oxygen levels and will kill roots and lead to a shallow root system.

The structure and growth habits of roots have a pronounced effect on the

- size and vigor of the plants.
- adaptation to certain soils.
- response to cultural practices.

Because roots are out of sight, they are often out of mind. Their significance in plant health is widely overlooked. Eighty percent of all plant problems start with soil or root problems.

Functions

- Anchor and support plants.
- Absorb and conduct water and minerals.
- Store products of photosynthesis (carbohydrates, sugars, proteins).
  - Winter survival of perennials
- Horticultural uses including:
  - food and feed,
  - propagation, and
  - soil erosion control.

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Putting Knowledge to Work

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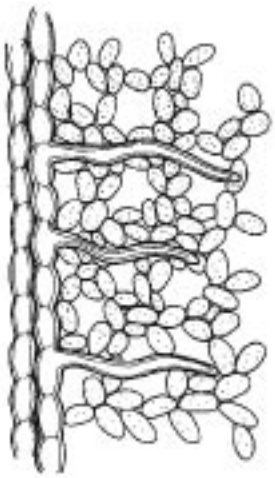

Figure 1. Root hairs are an extension of the epidermis.

Structure

Epidermis – the outer layer of cells.

Root hairs – an absorptive unicellular extension of epidermal cells of a root. These tiny, hair-like structures function as the major site of water and mineral uptake. Root hairs are extremely delicate and subject to desiccation. Root hairs are easily destroyed in transplanting.

Cortex – primary tissues of a root bound on the outside by the epidermis and on the inside by the endodermis. In a carrot, the cortex becomes a storage organ.

Endodermis – a single layer of cells in a root that separates the cortex tissues from the pericycle.

Pericycle – a layer of cells immediately inside the endodermis. Branch roots arise from the pericycle.

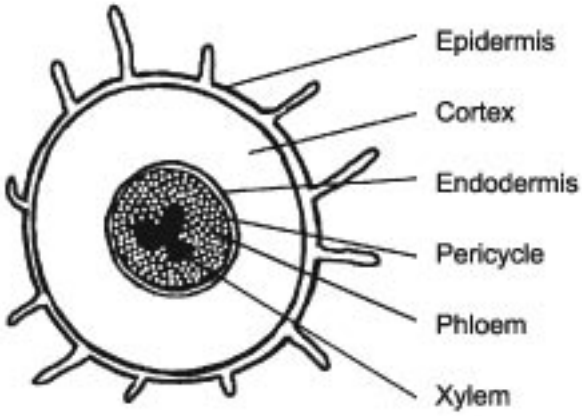

Figure 2. Plant structure and vascular system.

Vascular System

Phloem – tissue conducts products of photosynthesis from leaves throughout plant.

Xylem – tissues conducting water and minerals up from the roots

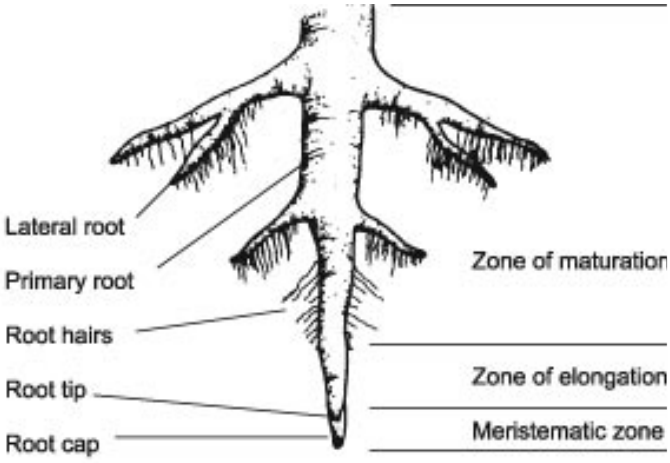

Figure 3. Diagram of a root.

Zone of maturation – Pipeline section of the roots, conducting water and nutrients from the root hairs up to the stems.

Zone of elongation – area where new cells are enlarging

Meristematic Zone

Root tip meristem – region of cell division that supports root elongation found at the root tips, just behind the root cap.

Root cap – A thimble-shaped group of thick-walled cells at the root tip serve as a hard hat to push though soil. The root cap protects the tender meristem tissues.

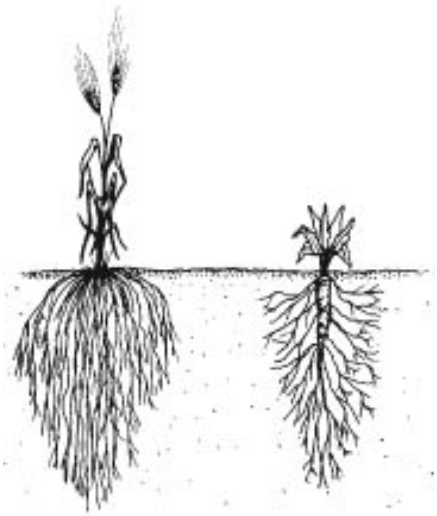

Figure 4. Fibrous root system of corn (left). Taproot system of carrot (right).

Types of Roots

Fibrous – profusely branched roots that occupy a large volume of shallow soil around a plant's base. (petunias, beans, peas)

Taproot – main, downward growing root, with limited branching, where soils permit. (carrots, beets, radish)

Combination – In nursery production the taproot of young plants (like oaks) is cut, forcing a fibrous growth pattern. This has a significant impact on the plant's ability to survive transplanting.

Adventitious roots arise at an unexpected place. For example, the brace roots on corn. Short whitish bumps along a tomato plant are adventitious roots.

Aerial roots arise from above-ground stem tissues. On English ivy and poison ivy, the aerial roots support the vine. Aerial roots are common on philodendrons, pothos, and Christmas cactus.

Lateral root – side root.

Sinker roots make a sharp dive into deeper soils, following soil cracks where oxygen is available. Sinker roots are common on some tree species.

Storage or Tuberous root – enlarged roots that serve as storage organs. (Canadian thistle, morning glory, sweet potato, dahlia)

Depth and Spread

The depth and spread of roots are dependent on the inherent growth characteristics of the plant *and* the soil's texture and structure. Roots require adequate levels of soil oxygen, so growth habit will be a factor of the soil's large pore space where oxygen is available.

- On compacted and clayey soils, roots will be shallow, remaining near the surface where oxygen is available.
- On droughty soils, the root system will spread farther, mining a larger soil area for moisture and minerals.

Note: tubers, bulbs and corms are technically stem tissues.

It is difficult to predict root spread of any plant. Under favorable growing conditions, the typical root spread of a tree includes:

- 90 to 95 percent in the top 36 inches.
- 50 percent in the top 12 inches.
- Spread 2 to 3 times a tree's height or canopy (drip-line) spread.

On compacted clayey soils, the typical root spread of trees includes:

- 90 to 95 percent in the top 12 inches or less.
- 50 percent in the top 4 inches.
- Spread may be 5 or more times the tree's height or canopy (drip-line) spread.

Some plants are genetically programmed to have very deep, spreading roots systems (i.e., they are more tolerant of low soil oxygen levels). This growth habit is an environmental adaptation. Examples include bindweed and prairie grasses.

Soil type is a key factor of water penetration and root uptake. Where soil allows, the primary water extraction depth extends to:

- 18 to 24 inches for flowers.
- 24 inches for turf.
- 24 inches for vegetables.
- 24 to 60 inches for shade trees.

Figure 5. Typical rooting pattern of trees, shallow and spreading.

Beneficial Microorganism Associations

Mycorrhizae are specific beneficial soil fungi forming symbiotic (mutually beneficial) associations with roots. While the role of mycorrhizae is not fully understood, they function to expand the root's contact with the soil profile, enhancing water and nutrient uptake. For additional information, see fact sheet 7.720, *The Living Soil*.

Rhizobium is beneficial soil bacteria that form a symbiotic relationship with plants, primarily those in the bean/pea family. These bacteria make atmospheric nitrogen available to plants. Rhizobium typically form nodules on the roots of plants. These may be mistaken for insect injury or deformity. When alfalfa, a member of the bean/pea family, is left to mature then tilled into a field, it is considered *green manure* because the plant is rich in nitrogen due to the rhizobium in the roots.

Colorado Master Gardener training is made possible, in part, by a grant from the Colorado Garden Show, Inc.

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