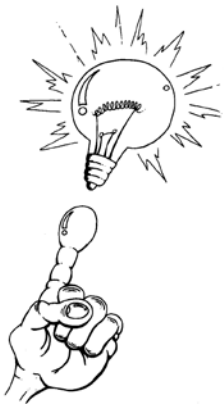
MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG GardenNotes #132

Plant Structures: Roots

Outline:



Thought questions:

Explain the science behind the question.

- Last summer during a home remodeling project we raised the soil level 12" 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 are the above ground symptoms of root and soil related

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 around 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 soil oxygen. Soil compaction or waterlogged soil situations, reducing soil oxygen levels, will kill roots and lead to a shallow root system.

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

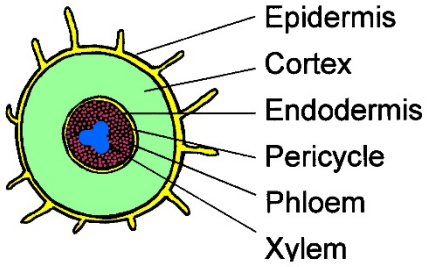
- Size and vigor of the plants
- Adaptation to certain soils
- Response to cultural practices

Because they are out of sight, roots are often out of mind. They are widely overlooked as to their significance in plant health. The majority of all plant problems start with soil/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
    - Food and feed
    - Propagation
    - Soil erosion control

Structure



Epidermis – The outer layer of cells

Root hairs – Absorptive unicellular extensions of epidermal cells of a root. These tiny, hair-like structures function as the major site of water and mineral uptake. Root hairs are very delicate and subject to desiccation. Root hairs are easily destroyed in transplanting. [Figure 1.]

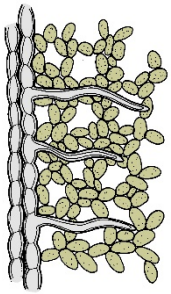


Figure 1. Root hairs are an extension of the epidermis.

Cortex – Primary tissues of a root bordered 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.

Vascular system

Phloem tissue conducts products of photosynthesis from leaves throughout plant including down to the roots.

Xylem tissue conducts water and minerals up from the roots up through the plant.

Zone of maturation – Area where cells form distinct tissues that become functioning roots.

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 serves as a "hard hat" to push though soil. The root cap protects the tender meristem tissues.

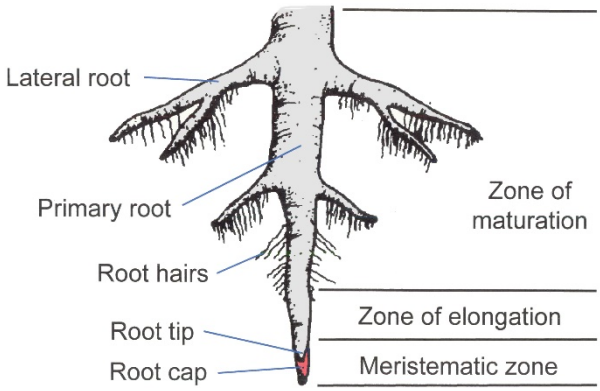


Figure 2. Lateral view of root

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, radishes).

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

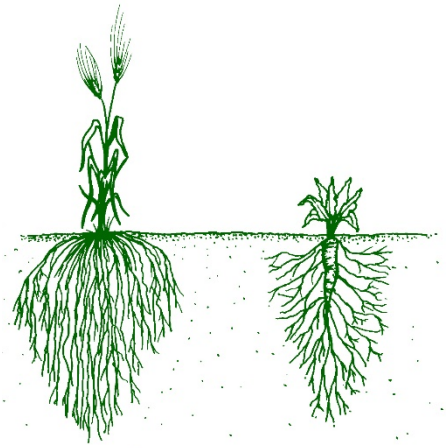


Figure 3. Root types –
Left: Fibrous root system of corn
Right: Taproot system of carrot

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 (Canada thistle, morning glory, sweet potato, dahlia).

Depth and Spread

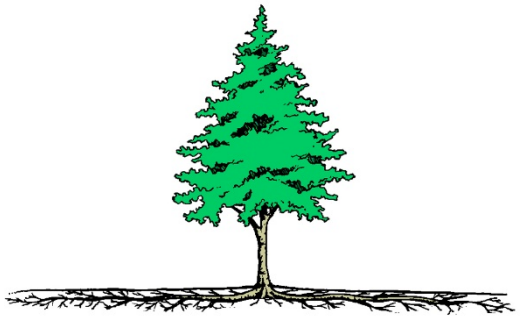
The depth and spread of roots are dependent on the inherent growth characteristics

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.

- In compacted and clayey soils, roots will be shallow, remaining near the surface where oxygen is available.

- In droughty soils, the root system will spread farther, mining a larger soil area for moisture and minerals.

Figure 4. Typical rooting pattern of trees, shallow and spreading



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

- 90-95% in top 36 inches
- 50% in top 12 inches
- Spreads 2-3 times tree's height or canopy (drip-line) spread

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

- 90-95% in top 12 inches or less
- 50% in top 4 inches
- Potentially spreads five plus times the tree's height or canopy (drip-line) spread

Some plants are genetically programmed to have very deep, spreading root 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 in water penetration and root uptake. Where soil allows, the primary water extraction depth extends to:

- Flowers 18-24"
- Turf 24"
- Vegetables 24"
- Shade trees 24-60"

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, refer to the CMG GardenNotes #212, *The Living Soil*.

Rhizobium is a beneficial soil bacterium that forms a symbiotic relationship with plants, primarily those in the bean/pea family. These bacteria make atmospheric nitrogen available to plants. *Rhizobium* typically forms 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 R*hizobium* in the roots.

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