Roots- Underground Agents

Dr. J. W. Tanner
Associate Professor of Crop Science
University of Guelph, Guelph, Ontario
Reprinted from Plant Food Review

Root Anatomy Interesting

First to emerge from a germinating seed is the primary root. It may, through branching, produce second, third, fourth order roots, etc., which may constitute all or part of the root system.

In the grass family the root system is augmented by the secondary root system which arises from stem nodes below or even slightly above the soil surface. These adventitious roots frequently constitute the main root system of the plant, such as in the case of corn where the primary system ceases to develop.

The root system may be of two types - tap or fibrous. It may be deep or shallow, sparse or dense, depending on the plant species, and upon environment. It may be concentrated in the surface few inches or well distributed throughout a much deeper root zone. Some tap-rooted plants may penetrate to depths of up to 30 feet, as in the case of alfalfa.

How Roots Grow

There are four distinct regions to a root's anatomy (Figure 1). At the root tip there is a thimble-shaped group of cells called the root tip. It protects the second region or the type of tissue at the root tips known as the meristematic cells. By cell division, this meristematic tissue replenishes both the root cap cells, which slough off as roots grow through the soil, and the cells which cause root elongation.

The area of cell enlargement is immediately behind the meristematic region. In this zone there is rapid cell enlargement resulting from rapid production of protoplasm and vacuoles, two principal cell components. Behind the zone of cell enlargement is the zone of maturation where the cells develop specific differences in structure and function. In this process, often called differentiation, some cells become vascular tissue (phloem and xylem), others become parenchyma (pith) and epidermal cells.

It is in the young part of the maturation zone that root hairs develop. These are slender extensions of single root epidermal cells (see Figure 2). Root hairs grow fairly rapidly and their life span is usually quite short, only a day or two for most crop plants. They grow in great profusion in the area immediately above the zone of elongation and, as the root extends, new root hairs are continually produced as older ones become non-functional.

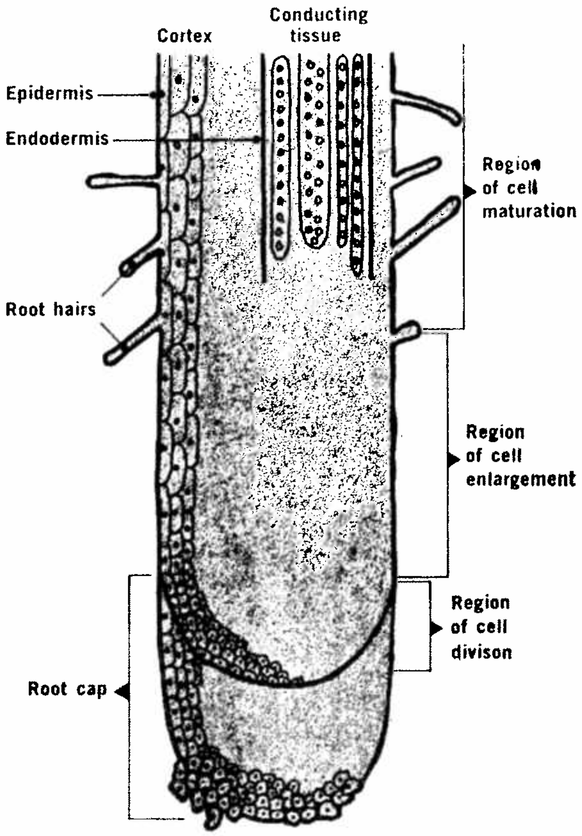
Root hairs greatly increase the surface area of roots, and function as the main site for water and nutrient absorption. Their rapid turnover enables the root to come into contact with daily supplies of nutrients and water.

Main Functions of Roots

The main functions of roots are absorption, anchorage and storage. Water and nutrient absorption have received by far the most research effort, and while there is abundant knowledge in the field there is much yet to learn. The importance of nutrient absorption to high yields has stimulated much of the research.

Storage of carbohydrates and other materials in roots is essential for the winter survival of biennial and perennial crops. Most of the commercial root crops (sugar beets, carrots) are biennials which are harvested at the end of the first growing year.

Longitudinal section of a young barley root.



As parts of the same living organism, it is obvious that there are close relationships between growth of plant tops and roots. As a plant develops, both top and root grow, but seldom at the same relative rate.

In general, the plant part nearest the source of an essential factor will be affected least by its deficiency. For example, when, because of low light intensity or defoliation, photosynthesis is retarded, root growth will be retarded much more than top growth. What little photosynthate that is produced under these conditions will be used mainly in the tops, and very little translocated to roots. Hence, the ratio of shoot to root increases.

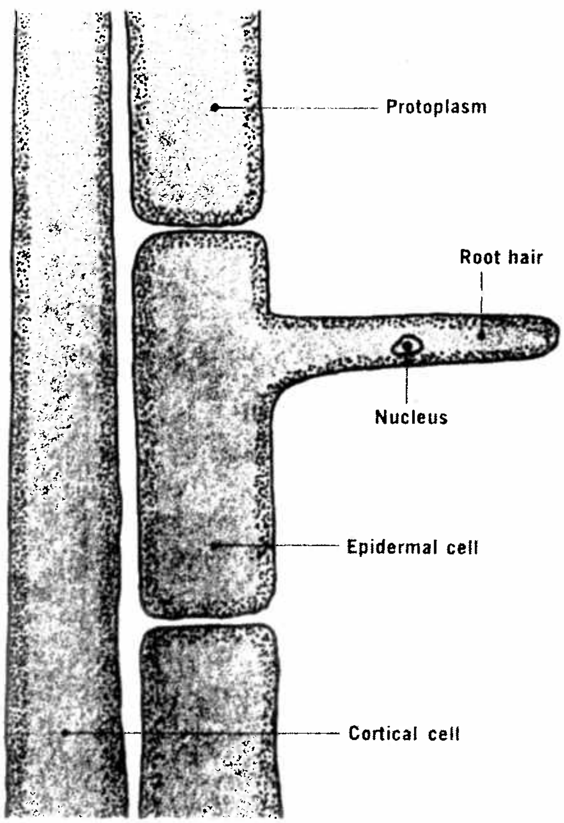
Conversely, when water or nutrients become limiting, the shoot, being further from the source, will be affected first and to the greatest extent. The equilibrium thus shifts in favor of the root, and the ratio of shoot to root decreases.

Other Functions of Roots

Metabolically, roots perform many functions essential to plant life other than absorbing nutrients and water. They are the primary site of nitrogen assimilation, and they can synthesize all their essential amino acids and proteins from inorganic nitrogen. Further, roots are the site of synthesis of many essential hormones, and of other important products. Among the latter is nicotine, an alkaloid produced only in roots of tobacco plants.

Other root functions include reproduction, toxic exudation and nodulation. Even though these three functions are not prevalent in all species, they are frequently vital to the survival and/or production of some. For example, growth of adventitious shoots from sweet potato roots provides for crop propagation.

Root epidermal cell showing root hair protruding.



Plant roots exude a wide range of organic compounds including alkaloids, vitamins, nucleotides, flavones, sugars, enzymes, auxins, amino acids and organic acids. Some of these may stimulate certain soil microorganisms, while they may be toxic to others. Their release is important in the establishment of a rhizosphere: the highly active root-soil interface. It also has been shown that some plants produce exudates which are toxic to other plants. This ability to produce their own "herbicide" provides a very useful competitive advantage to some plants.

Nodule formation and its associated nitrogen fixation is one of the most important side-line functions of legume roots. Some of our best known crops, such as soybeans and alfalfa, could not be produced economically without symbiotic nitrogen fixation. Much of the improved pasture of the world depends upon the establishment and survival of nitrogen-fixing legumes.

In this symbiotic relationship of bacteria and plants, bacteria use energy supplied by carbohydrates of the plant to convert inert atmospheric nitrogen into a usable form.

Soil Factors Affect Growth

Soil physical conditions, soil chemical make-up, soil microorganisms, crop management, and crop breeding can greatly affect root growth.

Soil moisture and soil aeration are inversely related: as one increases the other decreases. Some crops, such as rice, have roots that develop in standing water. Others, tobacco for example, are very sensitive to poor drainage and aeration.

Soil acidity is a very significant factor influencing roots. As degree of acidity increases, so does the amount of certain toxic elements in the soil solution. Notable among these is aluminum which, in acid soils, can greatly reduce plant growth as a result of its toxic effects on roots.

Placement of fertilizer too can modify root development. When banded, root density in the area of the band is increased. Yet, the total root production is probably no greater than that obtained from the same amount of fertilizer broadcast and disked in. While band replacement might result in earlier growth, broadcast fertilization usually results in a more extensive root system.

Roots are probably attacked by more disease organisms and insects than are the above-ground parts. In general, the main effect of such pests is a reduction of effective root surface for absorption. In severe cases root damage may be so severe that many roots die, new ones fail to develop, and existing ones become ineffective.

Roots Can Be Improved

Roots can be changed through plant breeding. One can cite many examples of the genetic improvement of plant roots with regard to lodging resistance, beet size and shape, degree of branching, etc. Less obvious changes have undoubtedly been made in ability to absorb nutrients. In all likelihood, increases in yield brought about through plant breeding can be attributed in part to unknown improvements in the root. Increased understanding of those root factors which affect plant yield represent a real challenge to those interested in pushing existing yield barriers aside.

Soil Fungicides

Although carnations in California do not readily show symptoms due to root damage by water mold organisms (Pythium and Phytophthora species), the presence of such organisms can reduce production.

In separate tests conducted at the Ken Fujii range in Hayward and at Tack's Greenhouses in Santa Clara, the routine application of soil fungicides beginning at time of planting resulted in some improvements in production patterns. In both tests, a new fungicide - Terrazole* - and a commonly used fungicide - Dexon - were applied at a high and low rate for each material in addition to untreated plots. At Tack's Greenhouses the natural condition prevailed while at Fujii's the soil was inoculated with water mold organisms. In the latter, plots which were not treated and not inoculated were also included.

In the Santa Clara tests, there were no significant differences between untreated and Dexon-treated plots, but highly significant increases in production for both levels of Terrazole. There were no significant differences between treatment levels of Terrazole. For a six-month period of production, the average yield of Terrazole-treated plots was 3.25 flowers per square foot more than for the average of all untreated and Dexon-treated plots.

In the Hayward experiment, all treatments resulted in significant improvements in production when compared to the control plots, but only the low rate of Terrazole and the low rate of Dexon yielded significantly more blooms than the non-inoculated, non-treated plots. Terrazole was slightly phytotoxic at both levels.

Terrazole is a relatively insoluble soil fungicide which does not have registration for ornamentals at this time. Dexon is registered as a soil drench for ornamentals. This progress report on experimental work now under way with these fungicides for carnations does <u>not</u> constitute a recommendation for their use. It does indicate, however, that there may be opportunities to increase carnation production through fungicidal programs.

From - FLOWER AND NURSERY NOTES, Agricultural Extension Service, University of California.

Your editor,

W D Holley

*5-ethoxy - 3-trichloromethyl - 1,2,4-thiadiazole. Product of Olin.

COLORADO FLOWER GROWERS ASSOCIATION, INC.
OFFICE OF EDITOR
W. D. Holley
Colorado State University
Fort Collins, Colorado 80521

FIRST CLASS