ing of two of the chambers will be a solid bank of fluorescent light (with a few incandescent lights) which is planned for an output of 2000 foot candles. In these chambers it will be possible to grow plants through their entire life cycle. The other two chambers are equipped with low intensity fluorescent and incandescent lights which will be useful for photoperiod studies. All lights are automatically turned off and on by time clocks. The envelope temperature of the fluorescent tubes in the high light intensity chambers will be kept constant at most efficient operating temperature regardless of room temperature. To accomplish this the lights are separated from the chamber by a glass ceiling and the temperature is controlled above this ceiling by an automatic damper and blower system which allows cooling air to pass over the lights when necessary.

"Attached to these controlled environment chambers are two 36' x 95' free span greenhouses of steel frame and aluminum bar construction. One of these is divided into three chambers which will allow for 3 temperatures. All chambers will be ventilated with smog-filtered, evaporative-cooled, forced air. The greenhouse has a concrete floor which will facilitate moving plants on carts to and from the controlled environment rooms and between chambers. With the three greenhouse chambers and the controlled environment rooms, it will be possible to subject plants to numerous combinations of well controlled environments. Experience at the Earhart Plant Research Laboratory of the California Institute of Technology has proven the worth of such controlled environments for plant research.

"Laboratories are located on the floor above the controlled environment rooms. There are five office-laboratories for individual staff members. There is a general biochemistry laboratory, a small "hot" lab for preparation of radioactive plant materials, a counting room for radioactive counting, a general cytology-anatomy laboratory, and a sterile culture laboratory with a transfer chamber.

"A small secretary-receptionist office, a conference room, and a plant and soil handling area complete the facility except for the machinery rooms and service area. The total floor area, including the greenhouses is 11,692 sq. ft."

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The Role Of Water In Plant Growth

BY DR. MARVIN H. FERGUSON
Mid-Continent Director, National Research Coordinator, USGA Green Section

Water is the most abundant material in a growing plant. The weight of water contained in a plant is usually four or five times the total weight of dry matter. Water is one of the constituents of many of the complex substances found in plants but it is interesting to note that liquid water is never found in a pure state in the environment of living organisms.

The essentiality of water is readily apparent. It has many functions in the plant.

It is a solvent for mineral nutrients and the complex substances manufactured within the plant.

It is a transportation agent and the means whereby the equilibrium of salts and other dissolved products is maintained between the various plant parts.

It is a raw material for the process of photosynthesis—the basic process underlying all life.

It acts as a temperture regulator in that water vapor given off by

leaves produces a cooling effect.

It even acts as a structural agent. When plant cells contain an abundance of water they are turgid and the plant stands erect; when there is a moisture deficiency, the cells are flaccid and the plant droops and wilts.

We think of protoplasm as being one of the basic materials of life in all organisms whether plant or animal. Protoplasm is that material contained within each living cell. This is an extremely active material and the protein and other substances of which protoplasm is composed becomes inactive and lifeless without water. This relationship may be visualized by considering the protein in a fresh egg white as compared to that in the dry and powdered form.

We may consider the effect of water on protoplasm by using a seed as an example. As seeds mature their water content is reduced. A mature seed actually is living but it is in a relatively inactive state. It lives but does not grow. When water enters the environment of the seed water is imbibed, enzyme activity begins to take place, the seed germinates and begins growth to produce a living and active plant.

Water outside the plant, as well as that contained within the plant, performs an important role in the growth and well being of the organism. Water dissolves the soil minerals which are essential to plant growth and the major part of plant nutrients are believed to be taken into the plant while they are in solution. Water moving through the soil performs a function in the flushing of pore spaces. As water moves downward in the soil it replaces the gases, such as carbon dioxide, which occupy pore spaces and as the water drains out of soil more air is drawn in, thus it aids in gas exchange and in bringing oxygen into the root environment. It is known that roots make their best growth in a moist soil, and numerous observations indicate that roots will not penetrate a soil that is completely dry. Vapor in the atmosphere surrounding the aerial parts of plants has a great deal to do with their performance and growth because of the fact that transpiration is affected greatly by the humidity and surrounding temperature.

Because of the fact that water is essential in the performance of several functions of a plant, it is not possible to consider any one of these functions as more important than the other. In its function as a solvent, water dissolves the mineral elements in the soil which are taken into the plant roots. Then, in its role of a transportation agent, water moves these dissolved minerals upward through the plant to the stems and leaves where they are used in the synthesis of complex compounds. The manufactured materials from plant leaves are moved downward through the plant to the roots, crowns and stems; thus, water serves as a dissolving agent for both simple and complex materials and as a transportation agent for these same materials. By passing through the membranes of the cell walls, water helps to maintain in equilibrium the dissolved substances.

Water is one of the raw materials whereby carbohydrates are manufactured from carbon dioxide and water in the presence of light through the process of photosynthesis. The hydrogen for the manufacture of carbohydrates is contributed by the water. Carbohydrates are represented by the sugars and starches, which are components of other more complex compounds, and by cellulose which

COMING EVENTS

December 7-8-9
14th Annual Texas Turfgrass Conference
Texas A. & M. College
College Station, Texas
Dr. Ethan C. Holt

1960

January 5-6
Mid-Atlantic Turfgrass Conference
Lord Baltimore Hotel
Baltimore, Maryland
Dr. George S. Langford

January 18-21
Rutgers-New Jersey Turfgrass Course
Rutgers University
New Brunswick, N. J.
Dr. Ralph E. Engel

January 28-February 6
31st Annual Conference
Golf Course Superintendents of America
Shamrock Hilton Hotel
Houston, Texas
Dr. Gene C. Nutter

January 29
USGA Green Section Educational Program
New York, N. Y.

February 15-18
Penn State Turfgrass Conference
Penn State University
Univerity Park, Pa.

is the chief component of the plant skeleton. Other equally important but less abundant compounds are also classed as carbohydrates.

Water may be considered to have a function as a structural agent in that it maintains the turgor of plant cells. As long as the cells are filled tightly with water, the plant is a more or less rigid structure, but when they become less turgid through the loss of water, then the relatively thin walls of the skeletal components of the plant may not be rigid enough to keep it from drooping.

Many observers have found that turf trampled when it is in a wilted condition will be injured more severely than turf which has an adequate supply of moisture and in which the plants are turgid. A lack of turgor in plants also reduces the photosynthetic activity because leaves tend to roll or fold following a water loss, thereby reducing light and retarding this important process.

One of the important, but less frequently mentioned, functions of water is that of temperature control. Water is given off by the leaves through the process of transpiration, and the evaporation of this water is accompanied by cooling. This cooling effect helps to maintain a favorable temperature around the leaves of the plant.

Modifications of plants in relation to water environment is one of the important factors determining areas of adaptation of those plants. These modifications are also among the chief factors which determine management requirements of various plants.

Red fescue may be used as an example of a grass that will tolerate relatively drouthy conditions. The red fescue leaf has a heavily cutinized lower leaf surface. The top surface of the leaf is strongly ribbed and the stomates through which water is lost to the outside air are located at the bottom of the grooves in the leaf; therefore, when the leaf of red fescue begins to transpire rapidly and the guard cells lose their turgor, the grooves close and further water loss is retarded.

On the other hand, Kentucky bluegrass is not equipped with the same mechanism whereby it may protect itself from water loss and it is damaged much more seriously by drouth. The bluegrass leaf folds because of two rows of thin-walled cells called bulliform cells along either side of the midrib of the leaf; therefore the bluegrass plant wilts from water loss and may be permanently damaged.

Zoysia serves as an interesting example of a plant having a defense mechanism against water loss. Members of this genus have leaves which contain numerous parallel rows of thin-walled cells through which water loss occurs. The fact that these rows of cells are closely spaced causes the leaf to roll tightly in the presence of conditions causing rapid transpiration. The plant thus defends itself against continued water loss, but tight rolling of the leaves reduces the surface available for photosynthetic activity and growth is retarded. This is one of the reasons that Zoysia makes better growth in humid than in dry areas.

The mechanisms whereby water loss from plants is prevented are too numerous and varied to be discussed here, but the presence and effectiveness of such mechanisms have much to do with the range of adaptation of the turfgrasses that are used in this country.

Many other modifications affect the ability of a plant to grow and do well in a given set of environment conditions relative to water. Rice grows in standing water, whereas many plants would die because of a lack of oxygen in the root zone. Plants differ in the development of their root systems, some being able to extract a greater amount of the available soil water than others.

The grower of plants of any kind will do well to learn as much as possible about his particular species in relation to its water needs and its response to an abundance or a deficit of water in the soil, in the plant, and as humidity in the atmosphere surrounding the plant.

TURF MANAGEMENT

The book "Turf Management," sponsored by the United States Golf Association and edited by Prof. H. B. Musser, is a complete and authoritative guide in the practical development of golf-course turfs.

This 354-page volume is available through the USGA, 40 East 38th Street, New York 16, N. Y., the USGA Green Section Regional Offices, the McGraw-Hill Book Co., 350 West 42nd Street, New York 36, N. Y., or local bookstores. The cost is $7.