BOTANY, PLANT PHYSIOLOGY AND PLANT GROWTH
Lesson 8: ENVIRONMENTAL FACTORS

The environment limits plant growth and distribution. If any one environmental factor is less than ideal, it will become a limiting factor in plant growth. Limiting factors are also responsible for the geography of plant distribution. For example, only plants adapted to limited amounts of water can live in deserts. Most plant problems are caused by environmental stress, either directly or indirectly. Therefore, it is important to understand the environmental aspects that affect plant growth. These factors are light, temperature, water, humidity and nutrition. In the subsequent lesson, we will discuss nutrition.

Segment One - Effect of Light on Plant Growth

Light has three principal characteristics that affect plant growth. These are light quantity, light quality and light duration.

- Light quantity refers to the intensity or concentration of sunlight and varies with the season of the year. The maximum is present in the summer and the minimum in winter. The more sunlight a plant receives, up to a point, the better capacity it has to produce plant food through photosynthesis. As the sunlight quantity decreases, the photosynthetic process decreases. Light quantity can be decreased in a garden or greenhouse by using shadecloth above the plants. It can be increased by surrounding plants with reflective material, white backgrounds or supplemental lights.

- Light quality refers to the color or wavelength reaching the plant surface. Sunlight can be broken up by a prism into respective colors of red, orange, yellow, green, blue, indigo and violet. On a rainy day, raindrops act as tiny prisms and break the sunlight into these colors, producing a rainbow. Red and blue light have the greatest effect on plant growth. Green light is least effective to plants as they reflect green light and absorb none. It is this reflected light that makes them appear green to us. Blue light is primarily responsible for vegetative growth or leaf growth. Red light, when combined with blue light, encourages flowering in plants. Fluorescent light or cool white is high in the blue range of light quality and is used to encourage leafy growth. Such light would be excellent for starting seedlings. Incandescent light is high in the red or orange range, but generally produces too much heat to be a valuable light source. Fluorescent grow lights have a mixture of red and blue colors that attempt to imitate sunlight as closely as possible but they are costly and generally not of any greater value than regular fluorescent lights.

- Light duration refers to the amount of time that a plant is exposed to sunlight or the lack of it and designated “photo-period”. When photo-period was recognized it was thought that the length of periods of light triggered flowering. The various categories of response were named according to the light length (i.e. short day and long day). It was then discovered that it is not the length of the light period but the length of uninterrupted dark periods that is critical to floral development. The ability of many plants to flower is controlled by photo-period. Plants can be classified into three categories, depending upon their flowering response to the duration of light or darkness. These are short-day, long-day, or day-neutral plants. Short-day plants form their flowers only when the day length is less than 12 hours in duration. Short-day plants include many spring and fall flowering plants such as chrysanthemum and poinsettia. Long-day plants form flowers only at day lengths exceeding 12 hours (short nights). They include most of the summer flowering plants, as well as many vegetables including beet, radish, lettuce, spinach and potato. Day-neutral plants form flowers regardless of day length. Some plants do not really fit into any category but may be responsive to combinations of day lengths. The petunia will flower regardless of day length but flowers earlier and more profusely under long days. Since chrysanthemums flower under the short days of spring or fall, the method of manipulating the plant into experiencing short days is very simple. If long days are predominant, shade cloth is drawn over the chrysanthemum for 12 hours daily to block out light until flower buds are initiated. To bring a long-day plant into flower when sunlight is not longer than 12 hours, artificial light is added until flower buds are initiated.

Another aspect of the influence of light on plant growth is tropism, the permanent, directed movements resulting from external stimuli.

Types of tropism include:

- Phototropism - The bending of plants toward a unidirectional source of light. A growth movement toward light is called “positive” phototropism. A bending away from light is called “negative” phototropism. Roots are either light insensitive or negatively phototropic.
- Geotropism - The growth response to the stimulus of gravity. Roots grow down into the soil and are positively geotropic. Shoots grow upward and are negatively geotropic.
- Thigmotropism - Refers to the directional growth caused by plants touching a solid object. This response is exhibited by climbing plants such as English Ivy, which send out aerial roots when a shoot comes in contact with a wall. The aerial roots attach the plant to the surface of the wall so it can continue to climb upward.

Segment Two - Effect of Temperature on Plant Growth

Temperature affects the productivity and growth of a plant, depending upon whether the plant is a warm or cool season crop. If temperatures are high and day length is long, cool season crops such as spinach will flower. Temperatures that are too low for a warm season crop such as tomato will prevent fruit set. Adverse temperatures also cause stunted growth and poor quality vegetable production; for example, bitterness in lettuce is caused by high temperatures.

Sometimes temperatures are used in connection with day length to manipulate the flowering of plants. Chrysanthemums will flower for a longer period of time if daylight temperatures are 59°F (15°C). The Christmas cactus forms flowers as a result of short days and low temperatures. Temperatures alone also influence flowering. Daffodils are forced to flower by putting the bulbs in cold storage in October at 35 to 40°F (2 to 4°C). The cold temperatures allow the bulb to mature. The bulbs are transferred to the greenhouse in midwinter where growth begins.

Thermoperiod refers to a daily temperature change. Plants respond to and produce maximum growth when exposed to a day temperature that is about 10 to 15° higher than night temperature. This allows the plant to photosynthesize (build up) and respire (break down) during optimum daytime temperature and to curtail the rate of respiration during a cooler night. Temperatures higher than needed cause increased respiration, sometimes above the rate of photosynthesis. This means that the products of photosynthesis are being used more rapidly than they are being produced. For growth to occur, photosynthesis must be greater than respiration.

Too low temperatures can produce poor growth. Photosynthesis is slowed down at low temperatures. Since photosynthesis is slowed, growth is slowed and this results in lower yields. Not all plants grow best under the same temperature range. For example, snapdragons grow best at a nighttime temperature of 55°F (12°C) and poinsettias at 62°F (17°C).

In some cases, a certain number of days of low temperature are needed by plants in order to grow properly. Peaches are a prime example: most varieties require 700 to 1,000 hours below 45°F (7°C) but above 32°F (0°C) before they break their rest period and begin growth. Lilies need 6 weeks of temperatures at 33°F (1°C) before blooming.

Plants can be classified as either hardy or non-hardy depending upon their ability to withstand cold temperatures. Winter injury can occur to non-hardy plants if temperatures are too low or if unseasonably low temperatures occur early in the fall or late in the spring. Winter injury may also occur because of desiccation or drying out. Plants need water during the winter. When the soil is frozen, the movement of water into the plant is severely restricted. On a windy winter day, broadleaf evergreens can become water-deficient and the leaves or needles then turn brown also, and more likely caused by temperature changes. Wide variation in winter temperatures can cause premature bud break in some plants and consequent fruit bud freezing damage. Late spring frosts can ruin entire peach crops. If temperatures drop too low during the winter, entire trees of some species are killed by freezing and splitting of plant cells and tissues.

Review of Temperature Effects on Plant Growth:
Photosynthesis:..........increases with temperature (to a point).
Respiration:................rapidly increases with temperature.
Transpiration:............increases with temperature.
Flowering: ....may be partially triggered by temperature.
Sugar storage: ....low temperatures reduce energy use and increase sugar storage.
Break dormancy:........after a period of low temperature, dormancy will be broken and the plant will resume active growth.

Segment Three - Importance of Water

As mentioned earlier, water is a primary component in photosynthesis. It maintains the turgor pressure or firmness of tissue and transports nutrients throughout the plant. In maintaining turgor pressure, water is the major constituent of the protoplasm of a cell. By means of turgor pressure and other changes in the cell, water regulates the opening and closing of the stomates, thus regulating transpiration. Water also provides the pressure to move a root through the soil. Among water's most critical roles is that of solvent for minerals moving into the plant and for carbohydrates moving to their site of use or storage. It is important in the chemical reactions of photosynthesis and respiration. By its gradual evaporation from the surface of the leaf near the stomate, water helps stabilize the temperature of the plant.

Relative Humidity is the ratio of water vapor in the air at a given temperature and pressure, to the amount of water the air could hold at that temperature and pressure, expressed as a percent. For example, if a pond of air at 75°F could hold 4 grams of water vapor and there are only 3 grams of water in the air, then the relative humidity (RH) is:

RH= water in air/water air could hold (at constant temperature and pressure)
or
RH= 3/4 = .75 expressed as a % = 75%

Warm air can hold more water vapor than cold air; therefore, if the amount of water in the air stays the same and the temperature increases, the relative humidity decreases.

Water vapor will move from an area of high relative humidity to one of low relative humidity. The greater the difference in humidity the faster water will move.

The relative humidity in the air space between the cells within the leaf approaches 100%; therefore, when the stomate is open the water vapor rushes out. As water moves out a bubble of high humidity is formed around the stomate. This bubble of humidity helps slow down transpiration. If winds blow the humidity bubble away, transpiration will increase.

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