Photosynthesis - Light, Temperature and Water

Light has three principal characteristics that affect plant growth: quantity, quality, and 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 shade-cloth or shading paint above the plants. It can be increased by surrounding plants with white or reflective material or supplemental lights.

Light **quality** refers to the colour or wavelength reaching the plant surface. Sunlight can be broken up by a prism into respective colours of red, orange, yellow, green, blue, indigo, and violet. On a rainy day, raindrops act as tiny prisms and break the sunlight into these colours producing a rainbow. Red and blue light have the greatest effect on plant growth. Green light is least effective to plants as most plants reflect green light and absorb very little. It is this reflected light that makes them appear green. Blue light is primarily responsible for vegetative growth or leaf growth. Red light when combined with blue light encourages flowering in plants. Fluorescent or cool-white light is high in the blue range of light quality and is used to encourage leafy growth. These lights are 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 colours that attempts to imitate sunlight as closely as possible. They are costly and generally not of any greater value than regular fluorescent lights.

Light **duration** or photoperiod refers to the amount of time that a plant is exposed to sunlight. When the concept of photoperiod was first 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 photoperiod.

Plants can be classified into three categories, depending upon their flowering response to the duration of darkness. These are short-day, long-day, or day-neutral plants. Short-day, (long nights) plants form their flowers only when the day length is less than about 12 hours in duration. Short-day plants include many spring and fall flowering plants such as chrysanthemum and poinsettia. Long-day, (short nights) plants form flowers only when day lengths exceed 12 hours. They include almost all 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 daylight. Since chrysanthemums flower under the short-day conditions of spring or fall the method for manipulating the plant into experiencing short days is very simple. If long days are predominant, a black plastic sheet 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 present longer than 12 hours artificial light is added until flower buds are initiated.

Temperature affects the productivity and growth of a plant depending upon whether the plant variety is a warm-season or cool-season crop. If temperatures are high and day length is long, cool-season crops such as broccoli and spinach will bolt rather than produce the desired flower. Temperatures that are too low or high for a warm-season crop will prevent fruit set. Temperatures that are too high for warm-season crops such as pepper or tomato can cause pollen to become in viable and not pollinate flowers. Adverse temperatures also cause stunted growth and poor quality. For example, the 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. The flowers are then ready for cutting in 3 to 4 weeks.

Thermo period refers to daily temperature change. Plants produce maximum growth when exposed to a day temperature that is about 10 to 15° F. (5.5 to 8°C) higher than the night temperature. This allows the plant to photosynthesize and respire during an optimum daytime temperature and to curtail the rate of respiration during a cooler night.

High temperatures 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.

Low temperatures can result in poor growth. Photosynthesis slows at low temperatures. Since photosynthesis is slowed, growth is slowed and this results in lower yields. Not all plants grow best in the same temperature range. For example, snapdragons grow best when night time temperatures are 55°F (12°C); the poinsettia prefers 62°F (17°C). Florist cyclamen does well under very cool conditions while many bedding plants prefer a higher temperature. Recently it has been found that roses can tolerate much lower night time temperatures than was previously believed. This has meant a conservation in energy for greenhouse growers. However, in some cases a certain number of days of low temperatures are needed by plants to grow properly. This is true of crops growing in cold regions of the country. Peaches are a prime example; most varieties require 700 to 1,000 hours below 45°F (7°C) and above 32°F (0°C) before they break their rest period and begin flowering and growth. If this cold requirement is not met then small, misshapen leaves and fruit will result. Many times fruit will not set. In low desert areas where these temperatures are not experienced low chill peach trees should be planted. Lilies need 6 weeks at 33°F (1°C or below) before they will bloom.

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 late in the spring or early in the fall. Winter injury may also occur because of desiccation (drying out).

Plant roots need moist soil during the winter. When the soil is frozen the movement of water into the plant is severely restricted. On a windy winter day broad-leaved evergreens can become water-deficient in a few minutes, turning the leaves or needles brown. Wide variations in winter temperatures can cause premature bud break in some plants and consequent freezing damage. Late spring frost damage can ruin entire crops. If temperatures drop too low during the winter, entire trees of some species are killed by the freezing of plant cells and tissue.

As mentioned earlier, water is a primary component of 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 stomata, thus regulating transpiration. Water also provides the pressure to move a root through the soil. Among water's most critical roles is that of a solvent for minerals moving into the plant and for carbohydrates moving to their site of use or storage. By its gradual evaporation of water from the surface of the leaf, near the stomata, helps stabilize plant temperature.

So, in conclusion, Light, Temperature and water all affect the rate of photosynthesis.