

None Like It Hot.

The recent period of hot temperatures may have affected corn and soybean yields more than assumed from observing stress symptoms of affected plants. Stress symptoms are almost always related to low water availability, but high temperatures can damage plants or reduce yields even if there is adequate moisture availability.

It is important to remember that plants react to temperature differently than humans. Humans must evaporate water to dissipate heat. High humidity reduces evaporation and greatly affects the way a particular temperature feels. Thus, weather stations report heat indices that are an attempt to estimate how air temperature “feels” to humans. High humidity translates into heat indices that are often five or more degrees above air temperature. Heat indices have little relationship to the effects of temperature on plants.

Sometimes leaf temperature is more important to plants than air temperature. Leaves function as solar collectors, that is, they are designed to absorb light energy. They do this in order to build sugars and produce other products necessary for life (and yield). However, very little of the light energy is actually used to do this work (photosynthesis). Light energy not used for photosynthesis causes leaf temperature to rise.

Plants dissipate heat through water evaporation from cell surfaces, convection, and conduction. Changing liquid water to water vapor requires substantial energy and this energy loss causes the cooling effect. Conduction means that the warm leaf surface warms (gives energy to) the air touching the leaf. Convection means that cooler air is moved closer to the leaf surface and displaces warmer air. These three methods of heat dissipation are very much interrelated, and without them the leaf temperature would quickly rise to the point where plants could not survive.

It is not uncommon for leaf temperature to be higher than air temperature, especially on bright sunny days with little wind. With good moisture supply, evaporation will be fast enough to keep leaf temperatures fairly close to air temperature. With limited moisture, stomates will close reducing water evaporation and increasing leaf temperature.

Nearly all of the chemical reactions necessary for the life of plants are controlled by enzymes. The rates of these chemical reactions increase with temperature, so, for example, plant growth and weight gain are greater at 80° than at 55°. These enzymes have a three-dimensional shape and can warp (change shape) at high temperatures. An extreme example of temperature affecting protein is the frying of an egg. The heat causes the egg protein to change its shape and become solid. The effect of temperature on plant enzymes isn't nearly that dramatic, but temperatures of 100 to 105 degrees can affect the shape of plant enzymes. When the shapes of the enzymes change, they no longer work as well. In other words, the reaction rate decreases. That is why 86° is often given as the optimum temperature for corn and soybean growth. Although the optimum is fairly flat for about 15 degrees, temperatures above the optimum slow many of the important reactions including those involved in photosynthesis.

So, high temperatures can harm crop plants and reduce yield. This direct affect from high temperature is probably small in most years, but when temperatures top 100° as they did several times in July, yield was reduced, at least slightly.

Unfortunately, high temperatures have other effects on plants. One almost hidden effect from increased temperature is the differential effects it has on photosynthesis and respiration. Photosynthesis is “income” for the plant world and respiration is an “expense”. The difference between the two, net photosynthesis, is “net income”. Within reason, high amounts of net photosynthesis often translate into high yield.

Some respiration is essential, just as some expenses are essential. Respiration oxidizes (“burns”) sugars to produce energy that is needed for many of the life processes. However, some respiration is wasteful because it burns away or oxidizes sugars that could have been stored in seeds as yield. Hot temperatures stimulate respiration more than photosynthesis and reduce the plant’s net income. This is particularly true during night when there is no photosynthesis. Warm night temperatures can decrease yield without showing any visible effects on the plants. Although high humidity can be beneficial to plants because water evaporation is reduced and this reduces water stress, high humidity also slows the rate by which temperatures cool at night. It is not uncommon for temperature to remain above 80° during summer nights if humidity is high (dew point above 65°). So, although plants do not “feel” a high heat index, they are affected by the slow temperature decline during nights of high humidity through increased respiration.

It is difficult to separate the effects of high temperature from the effects of water stress. Often these two stresses occur together and magnify the effects from each other. But, high temperatures can reduce yield even if plants exhibit no symptoms of water stress.