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Heat and Crop Development

Now that we're into the dog days of summer, we thought it would be interesting to think about how much heat corn can handle, how the heat is impacting corn development and growth and how the wind can be a factor as well.

Heat stress is a result of temperature, temperature duration and temperature timing.

The "dog days" of summer refer to a historically hot and humid weather in the Northern Hemisphere occurring between the first week of July and middle of August. (www.almanac.com)

HOW MUCH HEAT CAN CORN HANDLE?

Unlike canola (and other prairie crops), corn likes warmer summertime temperatures. Corn development its optimized at 30˚C. After 30˚C, photosynthetic efficiency is drastically reduced and at 45˚C, overall net photosynthesis is reduced by 50-90%.

Corn is a C4 plant, which means it has a higher optimum temperature for photosynthesis compared to C3 plants (canola, wheat, peas, etc.) At warmer temperatures, C4 plants are able to maintain their net photosynthesis levels, while C3 plants can not due to their increased **photorespiration*** rates. C4 plants maintain their net photosynthesis level at warmer temperatures because they have a mechanism to keep the enzyme **Rubisco*** active. However, above 30˚C the enzymatic activity of Rubisco quickly declines, resulting in a sudden drop of photosynthetic activity.

HOW MUCH HEAT CAN CORN HANDLE?

1. **Early Vegetative Growth (V5-7):** During early vegetative growth, the corn plant is finalizing the girth (# of kernels around) of the ear. Heat stress can negatively impact the girth, while optimal growing conditions can increase girth. Ear girth is a hybrid characteristic that is largely influenced by genetics but environmental stress early in the growing season can have an impact.
2. **Late Vegetative Growth (3-4 weeks prior to pollination):** The number of potential kernels long is being influenced during this period and stress events can reduce the ear length. Remember that these potential kernels all need to be pollination to contribute to yield.
3. **Pollination:** During the pollination and silking period of development, hot conditions pose a risk as these conditions can cause silk and pollen desiccation (at and above 35˚C) and pollination failure (at and above 38˚C). Importantly, pollen shed does tend to occur in the morning before daytime temperature highs are reached. Complete pollination failure results in no kernel development while partial pollination failure results in partial kernel development on the ear.
4. **Grain Fill – R2 & R3:** Heat stress during R2 & R3 (blister and milk stage) can reduce the number of kernels that are filled on the ear. Kernels will abort due to poor carbohydrate availability from overall reduced photosynthesis. Typically, the kernels that are last to be pollinated will be the first to abort, so expect to see aborted kernels at the tip of the ear.
5. **Grain Fill – R4 & R5:** Kernel size and weight is another yield influencing factor that will be affected with heat stress during R4 & R4 (dough and dent stage). During this period there is significant dry matter/ carbohydrate accumulation for the kernel. Heat stress can significantly impact kernel depth, ultimately effecting kernel size and kernel weight.

OTHER FACTORS IMPACTED BY HEAT STRESS:

1. **Reduced leaf area** – smaller leaves, less leaves or leaf-rolling because of heat and/or moisture stress resulting in reduced area available for photosynthesis
2. **Reduced plant height** – due to reduced internode lengths
3. **Corn silage quality** – higher fiber content, reduced fiber digestibility and reduced overall digestibility
4. **Corn silage yield:** in addition to reduced ear size causing reduced yield, further reduction in yield can be caused by reduced leaf size, less leaves, and shorter plants as approx. 35% of dry matter yield is from parts of the plant other than the ear (kernels, cob, husk)i

HOW DOES PRECIPITATION PLAY INTO LONG-LASTING HOT FORECASTS?

Heat stress is commonly supplemented with drought, in turn making it difficult to determine how the individual stresses effect development and ultimately yield. High temperatures cause plant **transpiration*** rates to increase, resulting in a higher demand for soil water due to a high **vapour pressure deficit*** between the air and the leaf canopy. To cope with high vapour pressures deficits, corn plants close their stomata, resulting in reduced photosynthetic efficiency. Timely rainfalls or irrigation can help lessen the heat stress damage by maintaining soil moisture levels, but it does not eliminate the damage

HOW DOES WIND PLAY INTO THESE LONG-LASTING HOT FORECASTS?

Wind is another factor that can intensify heat stress. On hot windy days, the water released from the plants via **transpiration*** is constantly being replaced by hot dry air. This is increasing the vapour pressure deficit between the air and the leaf canopy causing and increased rate of water being pulled from the plant. When winds are low on a hot day, the air above the leaf canopy becomes saturated with the water vapour released via transpiration. This saturated air does not stray far from the leaf canopy and with time decreases the **evapotranspiration*** rates, minimizing the heat stress damage.

Definitions*

Photorespiration: is the process in plant metabolism that uses some on of the energy the produced in photosynthesis in response to closed stomata; a result of higher ratio O_2 to CO_2

Vapour Pressure Deficit: the difference between how much water the air can "hold" compared to how much it is currently "holding"; combines relative humidity and temperature into 1 variable.

Transpiration: water lost from the plant stomata to the atmosphere; mechanism used by plants to avoid heat stress

Evapotranspiration: sum of the water evaporation from the soil and plant surfaces, the water used by the plant and transpiration

Rubisco (Ribulose-1,5-bisphosphate carboxylase-oxygenase): important enzyme required in one of the first steps on the photosynthetic reaction.

SUMMARY

In summary, in this article we focused on one environmental stress – heat stress. But remember that heat stress is usually paired with drought stress and other environmental stresses can have similar effects to corn yield potential.

As always, but especially now – be safe when you're in the field. Hit the fields during the cooler parts of the days, wear a hat and sunscreen and drink plenty of water.

Additional Reading:

- Corn Pollination and Fertilization
- Heat Stress Effects on Corn
- Ear Size Determination in Corn
- Corn Growth in Hot and Dry Conditions
- AGRIFacts- Crop Water Use and Requirements