CROP FOCUS

DuPont PIONEER

Solar Radiation in Corn Production

Solar Radiation and Crop Needs

- Along with water and nutrients, solar radiation (sunlight) is an essential input for plant growth.
- Plant leaves absorb sunlight and use it as an energy source in the process of photosynthesis.
- A crop's ability to collect sunlight is proportional to its leaf surface area per unit of land area occupied, or its "leaf area index (LAI)".
  - At "full canopy" development, a crop's LAI and ability to collect available sunlight are maximized.
- From full canopy through the reproductive period, any shortage of sunlight is potentially limiting to corn yield.
  - When stresses such as low light limit photosynthesis during ear fill, corn plants remobilize stalk carbohydrates to the ear. This may result in stalk quality issues and lodging at harvest.
- The most sensitive periods of crop growth (e.g., flowering and early grain fill) are often the most susceptible to stresses such as insufficient light, water or nutrients.

Cloud Effects on Solar Radiation

- Plants are able to use only a portion of the solar radiation spectrum. This portion is known as "photosynthetically active radiation (PAR)" and is estimated to be about 43% to 50% of total radiation.
- Amount of PAR available to a crop is reduced proportionately to cloud cover (Figure 1).

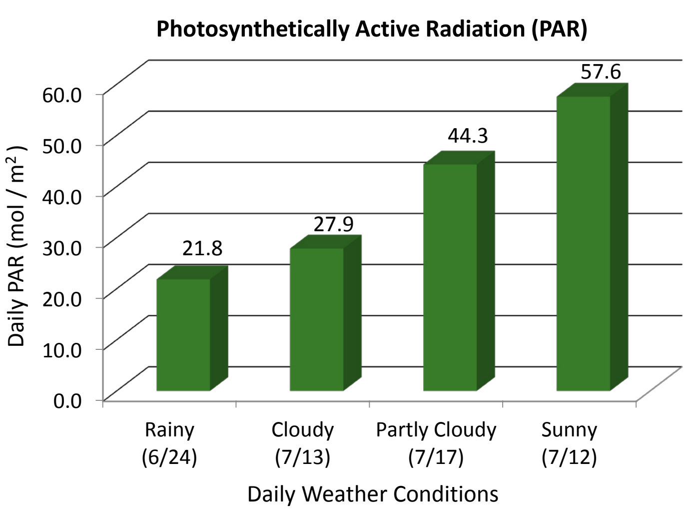

Figure 1. Daily PAR received in Johnston, IA under rainy, cloudy and sunny conditions on four different days in summer.

- As Figure 1 shows, PAR was reduced by 25% to 50% on partly cloudy to cloudy days, and by over 60% on rainy days.
- It is not surprising, then, that cloudy, rainy periods during susceptible stages of crop development can have significant effects on yield.

Effect of Shade on Corn Yield

- A study using "shade cloth" reduced solar radiation by 55% during various crop stages (Liu and Tollenaar, 2009).
- Yield was significantly reduced by shading at the silking and post-silking stages (Table 1).

Table 1. Effect of shade treatments on yield (Tollenaar, 2009.)

Shade period[1]	Yield reduction (%)
4 weeks pre-silking[a]	3.2% NS
3 weeks at silking[b]	12.6% **
3 weeks post-silking[c]	21.4% **

[1] Weeks relative to silking: [a] -5 to -1, [b] -1 to +2, [c] +2 to +5.
NS=not significant, **= highly significant, (Prob>F=0.05.)

- In another study, solar radiation was reduced by 50% using shade cloth (Reed, et al., 1988).
- Yield was significantly reduced by shading at the flowering and post-flowering stages.
- Shading during flowering reduced yield primarily through <u>decreasing the number of kernels per row.</u>
- Shading during grain fill reduced yield primarily through <u>decreasing kernel weight</u>.

Table 2. Effect of shade treatments on yield (Reed, et al, 1988.)

Shade period	% Yield Reduction	Change in kernels/row	Change in kernel wt.
Vegetative	12%	-5%	+1%
Flowering	20%	-21%	+9%
Grain fill	19%	-5%	-13%
LSD (.05)	7%	4.5%	6%

Average U.S. Solar Radiation

- Daily light integral (DLI) is the total amount of solar radiation received at a location each day.
- The southern vs. northern U.S. has higher DLIs in the fall and winter due to longer days and higher angle of the sun (Figure 2).
- From May through August, the primary DLI differences occur between the eastern and western U.S. (Figure 2).
  - Northern areas have longer days but a lower solar elevation angle, so DLI is about the same as in southern areas during most of the corn growing season.
- Elevation and regional weather patterns (primarily cloud cover and humidity) also contribute to regional differences.

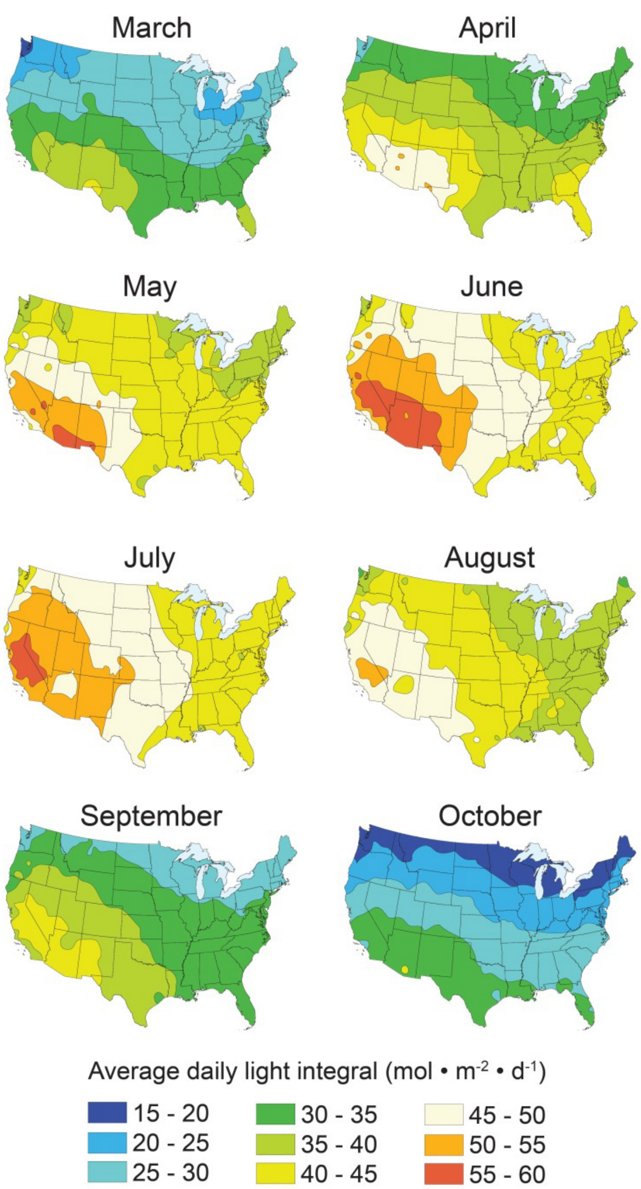

Figure 2. Average U.S. daily light integral (DLI) by month (Korczynski, et al., 2002).

2015 Growing Season and Solar Radiation

- Cloud cover and rainfall during vegetative, flowering and early kernel development reduced solar radiation during these stages in 2015 (Figure 3).
- Flowering generally occurred from 7/10 to 7/25 in the central Corn Belt, and from 7/20 to 7/31 in Northern states and Ontario.
  - This period (R1) and the very early kernel development stage that follows (R2 or "blister") are especially sensitive to environmental conditions.

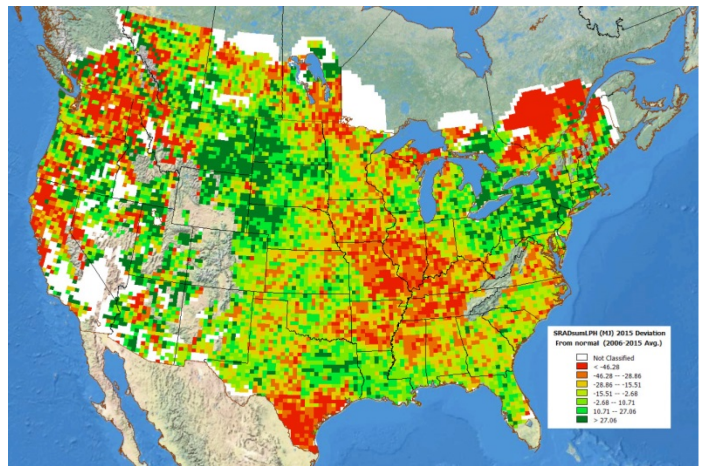

Figure 3. 2015 deviation from normal (2006-2015 avg.) solar radiation during the "lag phase" of development.

"Lag phase" is the time from pollination to the beginning of the linear phase of rapid dry matter accumulation in the kernel, and corresponds with the R1 (silking) through R2 (blister) stages of development.

- Solar radiation during early kernel development in 2015 was well below the 10-year normal in many locations.
- Research (see Tables 1 and 2) indicates that inadequate sunlight during this stage can result in decreased yield, primarily due to less kernels produced per ear ("nosing back").
- In addition to aborted ear tip kernels, lower sunlight during grain fill often results in lower kernel weights, poor stalk quality, and premature plant death.
  - Growers should monitor stalk quality and schedule harvest based on lodging potential, rather than just grain moisture.

References

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