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Corn Response to Drought and Heat Stress

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SUMMARY

- Long-term weather patterns affect corn growth, development, and yield.
- This article summarizes the current state of knowledge with emphasis on the Midwestern U.S.
- Periods of high heat and water deficit challenge the ability to maximize yield production.
- Agronomic recommendations to help alleviate the negative effects are discussed.

Overview and Introduction

Corn is a staple crop in the U.S., mostly grown in the Midwest, with production influenced by genetics, environment, and management. The summary focuses on how drought and heat stress reduce yield, especially under rainfed conditions, and the role of breeding and agronomic strategies in mitigating these effects. Several overarching factors include:

- Long-term stressors like drought and high temperatures are becoming more frequent.
- Variations in seasonal weather patterns affect growth during the growing season.
- Genetics and environment interact with management practices to influence productivity.

Drought and Heat Stress Impacts

Drought and heat events are intensifying due to weather shifts, leading to:

- Yield losses of up to 23%, especially during sensitive crop stages.
- Adverse effects during early growth, pollination, and grain filling (Figure 1).
- Higher sensitivity in rainfed areas with low precipitation like western Kansas and Nebraska.

Precipitation patterns are erratic, and higher temperatures increase evapotranspiration, reducing water availability.

Breeding and Genetic Advances

Corn breeding efforts have improved yield and drought resilience:

- Development of drought-tolerant hybrids like AQUAmax and Artesian materials.
- Traits include shorter anthesis-silking intervals, improved water use efficiency, and delayed leaf senescence.
- Drought-tolerant hybrids outperform conventional materials under moderate drought, especially around silking and pollination.
- However, under optimal conditions, conventional hybrids may yield more than drought-tolerant ones.

Figure 1. Contrasting corn field conditions during mid vegetative stages and tasseling. Image on the left shows a corn field with adequate water supply. Image in the center shows leaf rolling and cracked soil. Image on the right shows accelerated leaf senescence in the lower canopy due to drought stress. Photos: Osler Ortez, Ohio State University (left and center): and Mark Licht, Iowa State University (right).

Agronomic Management Strategies

Management practices at the farm level complement breeding improvements:

- Planting dates and maturities: varying dates and hybrid relative maturities to spread risk of stress around silking and pollination.
- Nutrient Management: adequate nutrient supply improves productivity, reduce nutrient losses, and can help mitigate drought negative effects.
- Plant Density: lower plant densities can decrease interplant competition and stress if water is a yield-limiting factor.
- Hybrid's differences: hybrids respond differently to stress and management, select hybrids best suited to your growing environments.
- Drought tolerance: If water is a limiting factor, select hybrids with drought-tolerance. Note that drought-sensitive and drought-tolerant hybrids can respond differently to plant densities.

Soil and Water Management:

- Conservation tillage helps retain soil moisture and builds organic matter.
- Controlled drainage and irrigation (if available) help optimize water use.
- Key stages like VT (tasseling) to R1 (silking) have the highest water demands—about 2 inches of water use per week (Table 1). Corn is most sensitive to drought-stress soon before, during, and after that period.

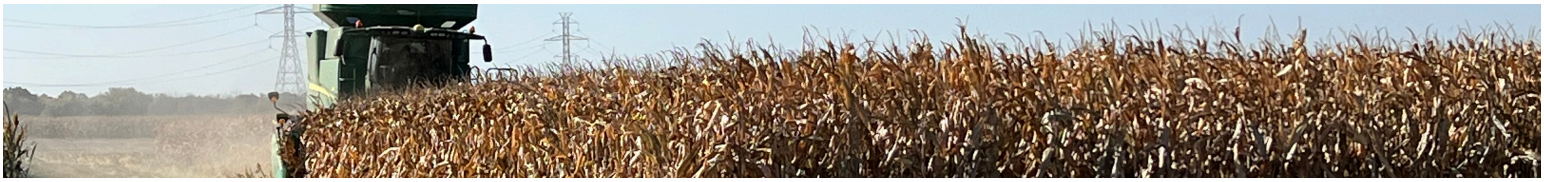

Table 1. Water use rates for corn at different growth and developmental stages using the leaf collar method. Adapted from Ohio State University.

Stage	Water Use Rate, Inches per day
Prior to 12-leaf stage (<V12)	<0.20
12-leaf stage (V12)	**0.24**
Early tassel (VT)	0.28
Silking (R1)	**0.30**
Blister (R2)	0.26
Milk (R3)	**0.24**
Dent (R5)	0.20

Table 2. Summary of management practices to help address drought and heat stress. Challenges associated with their implementation are also outlined.

Challenges	Management Practices
Extreme events like the widespread drought in 2012 decreased corn yields; especially rainfed and in the western US.	Higher yields of drought-tolerant hybrids under drought stress before pollination and up to physiological maturity relative to standard hybrids reported.
Unclear when stress occurrence will appear within a season, and the critical period is long (~1 week before to ~3 weeks after silking).	**Minimize the occurrence of stress during the kernel set period to optimize plant growth rate and ensure kernel numbers are preserved through varying hybrid relative maturities.**
Higher yields for drought-tolerant hybrids have not been consistent or have been even negative, in part attributed to different yield levels.	Drought-tolerant hybrids produced yield increase relative to a drought-sensitive if drought was present. Drought-tolerant hybrids with lower yield relative to the standard in well-watered conditions.
Yield advantages are reported in no-till systems in southern US; lower yields in no-till systems in northern US (attributed to colder and wetter springs).	**Conservation tillage has been recommended for soil conservation, water management, and building soil organic matter. Drainage options can help with the adoption of heavier textures with drainage issues. Some cover crop successes reported.**
Several factors are critical for efficient irrigation regimes and estimating crop water requirements in the field. The irrigation system approaches can be improved.	For the western corn belt, irrigation (mainly pivot irrigation) has been a key strategy to produce high corn yields. Water use limits in some districts to control how much water is used.
The cost, investment, and durability of controlled drainage structures. Added, the implicit variability as there are years when drainage is very useful and years when is not.	**Use of controlled drainage structures may help retain water to facilitate off-season soil moisture recharge and could possibly raise the water table to help alleviate short-term water deficit conditions.**

KEY TAKEAWAYS

- Drought-tolerant hybrids show promise, especially under moderate to high drought stress conditions.
- Management strategies like nutrient optimization, conservation tillage, and strategic irrigation can boost resilience.
- Challenges and associated management options are summarized in Table 2.

Further research is needed to:

- Fine-tune hybrid performance under current and future climate stress settings.
- Implement strategies to improve soil water retention and conservation.
- Explore alternative crops and rotations for diversification.

Reference

For more information on heat and drought stress in corn (and other long-term stressors), access:

- Ortez, O. A., Lindsey, A. J., Thomison, P. R., Coulter, J. A, Singh, M. P., Carrijo, D. R., Quinn, D. J., Licht, M. A., & Bastos, L. (2023). Corn response to long-term seasonal weather stressors: A review. Crop Science, 63, 3210–3235. https://doi.org/10.1002/csc2.21101

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