Mississippi Corn Promotion Board
2020 Progress Report

Title: Evaluating Corn Hybrids for Drought and Waterlogging

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Project Summary

Waterlogging and drought are prevalent events resulting from erratic rainfall and high/low temperatures throughout the Mid-southern US growing season. These two abiotic, or environmental stresses have been well documented, accounting for a majority of crop production losses for all agronomic crops across the United States over the past 20 years. These stresses have been proven to limit yield in corn production, with impacts worsening as duration and intensity increases. However, no systematic evaluation has been conducted to unravel precisely how these factors limit the plant growth, development, and physiology that ultimately prevent the crop from attaining its true yield potential. Without a thorough understanding of how these stresses affect our corn crop at the individual plant level, it will be challenging to strategize best management decisions and genetic improvements to close the yield gap and improve our production efficiencies under limiting conditions. This study provides the baseline research needed while ultimately pursuing more sustainable and profitable agricultural production.

Our research is rooted in the importance of establishing a vigorous, uniform crop stand early in the growing season to lay the foundation for a successful crop. The development of robust root systems and expansive photosynthetic machinery (plant canopy) is crucial as we push to increase yields, build stress tolerance, and increase crop inputs' efficiency. Strong early season growth establishes plants' capacity to tolerate better future environmental stress (drought, heat, flooding, ext.) and biotic stress (insects, pathogens, weeds, ext.) throughout the growing season. This growth also establishes plants' ability to efficiently uptake water and nutrients. Successful agronomic strategies have been established, such as early planting dates, split nutrient applications, and best hybrid selection; however, we still lack critical information to maximize these strategies' effectiveness, especially at a site-specific level.

Resources from this grant provided by the MCPB were combined with other funding sources (USDA-NIFA) during years 3 and 4 to broaden this study's scope to include the effects of temperature (low and high) and nitrogen at no additional expense to the MCPB. This expanded scope will provide valuable insight as the industry aims to optimize planting dates and nutrient application to a site-specific level.

Project Results/Outcomes

Throughout the past four years, we completed four experiments toward our goal of unraveling the effects of waterlogging and drought on corn growth and development. Four additional experiments were completed during years 3 and 4 expanding our study to include the impact of high/low temperature and nitrogen stress. Each stress was divided into two projects: one investigating multiple stress levels on a single hybrid, another differentiating the response among multiple high yielding corn hybrids from the Mississippi Variety Trial list.

Experiments investigating multiple levels of each stress provide insight into how individual plant growth aspects are impacted and the critical levels of each stress. The experiments produce information vital to planning management strategies to mitigate the adverse effects of such stress and strategizing genetic improvements to boost tolerance through breeding programs. Experiments conducted on multiple hybrids provide information on hybrid performance under stress beyond the traditional field trials already conducted. Hybrids will be scored and ranked based on their performance under each stress condition. Additionally, these studies' results will be cross analyzed with variety trial results to determine how hybrid performance under stress ultimately translates to overall performance in the field.

Drought: As drought stress occurred, plants were shorter, and canopies were thinner following a decrease in photosynthesis. Root architecture dramatically changed: roots grew deeper, with less branching.

Project Results

Flooding: Under waterlogged conditions, plant growth was hindered following a reduction in soil oxygen content. Soil oxygen rapidly declined until reaching zero after approximately six days. Above ground plant material experienced many symptoms of drought stress, despite an overabundance of water. Root growth became thinner and shallower.

Temperature: Corn responded quadratically to changes in temperature both above- and below-ground systems. As temperatures rose, growth increased until reaching the optimal temperature, and then declined as temperatures continued to rise. Cardinal temperatures were determined for each growth and development process.

Nitrogen: Leaf nitrogen levels impacted both above and below ground growth and influenced the plant's partitioning of resources to below ground structures. Growth declined quadratically as leaf N levels fell below optimal levels, and root growth was less sensitive than above-ground growth.

FUTURE PLANS

2021 is the FINAL year of this study. The proposed half-year extension will be utilized to complete the publishing process and disseminate results in formats usable to both the research and production community.

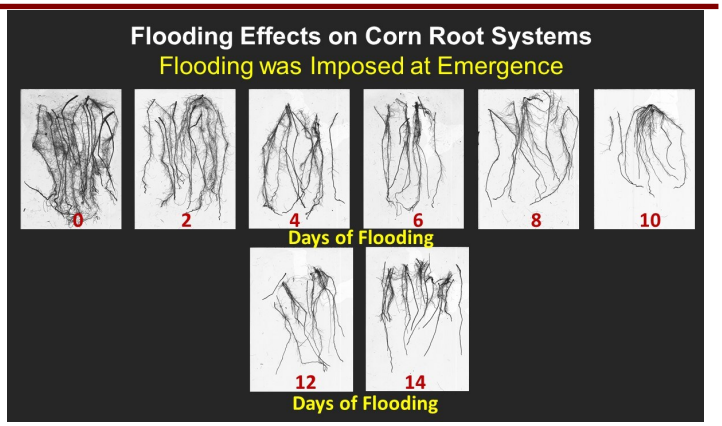

Fig.1 (*above*) depicts the effects of waterlogging on root growth. As waterlogging duration extended, roots grew thinner and shallower following a decline in soil oxygen content.

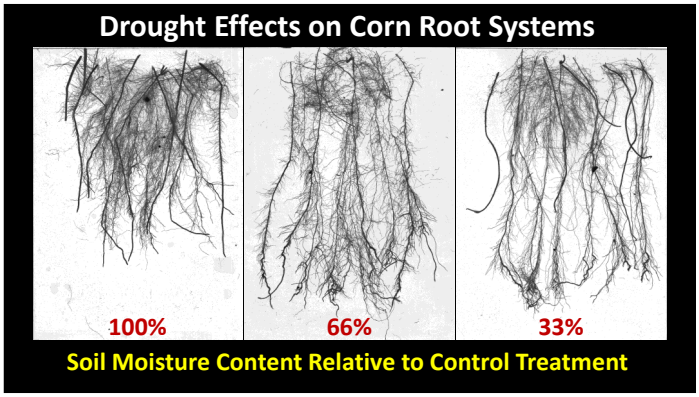

Fig. 2 (*right*) depicts the effects of drought on root growth. Total root volume, surface area, and number declined under drought, but root architecture dramatically changed. Roots grew deeper with less later branching as they mined for water and nutrients deeper in the soil.

Project Impacts/Benefits

Researchers: Data from this study aims to pinpoint exact mechanisms affected by environmental stress, especially roots that have not been studied to a great extent. Published results will establish baseline knowledge for future research to expand.

Producers: Data and results published in the form of extension bulletins will provide knowledge about how these stresses impact their crop and the value of efficient management strategies and tolerant varieties. Classification of stress tolerance among hybrids with proven high yield potential provides an additional resource for producers to use when selecting optimal hybrids for their operation.

Project Deliverables

In 2020, results from this study were published in two academic journals: Agrosystems, Geosciences, and Environment, and the Journal of the Mississippi Academy of Sciences. A third paper has been submitted to the Agronomy Journal.

Throughout this study, results have been disseminated at four national and five regional conferences via oral and poster presentations. Conference presentations were limited in 2020 due to COVID-19.

In 2021, we plan to finalize the publication of three to four additional peer-reviewed manuscripts. We also plan to compile our work results into multiple extension bulletins for direct and immediate dissemination for all.

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