Productivity of Drought-Tolerant Alternative Crops Subjected to Water-Limiting Conditions in West Texas

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Introduction

The declining water levels of the Ogallala aquifer and projected occurrences of prolonged water deficits in the future pose serious threats to agricultural productivity in West Texas. With the increasing population and increasing demand for food, fiber, and bioenergy resources, water-conservation strategies such as growing drought-tolerant and low input alternative crops together with high-value crops in semi-arid regions can be implemented to increase agricultural productivity, profitability, and extend the life of limited water resources.

In 2016, a preliminary study was conducted where sesame, pearl millet and cotton were evaluated under three deficit irrigation levels: extreme (51 mm), severe (127 mm), and moderate (203 mm).

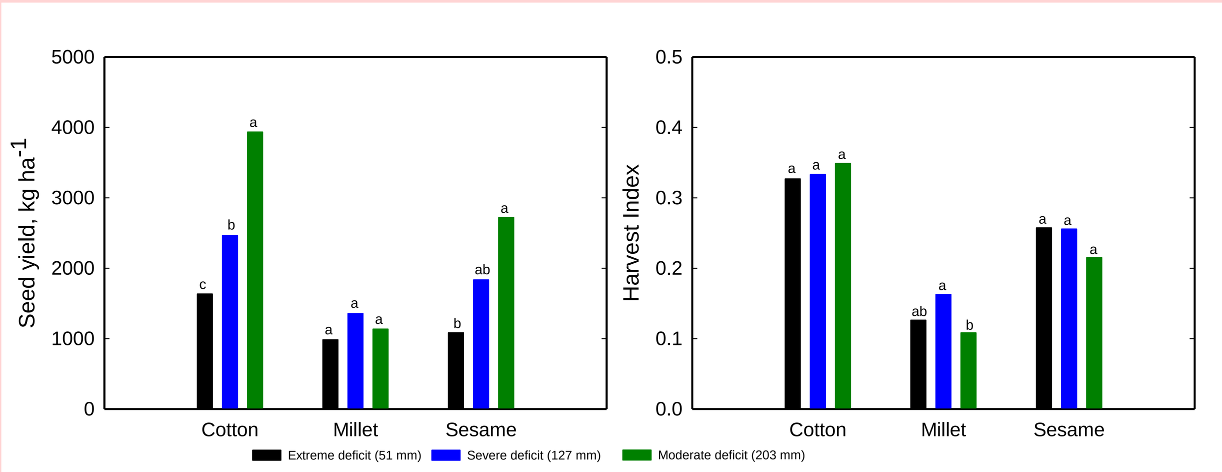

Figure 1. Comparison of seed yield and harvest index of cotton, pearl millet and sesame grown under 3 deficit irrigation levels in 2016 at Quaker Avenue Research Farm, TTU, Lubbock, TX.

As shown in Figure 1, unlike cotton, sesame and pearl millet do not need additional in-season irrigation to achieve their potential yields. Following up on these findings, we further evaluated additional drought-tolerant and low input alternative crops that may be profitable and well suited in semi-arid regions such as West Texas.

Objective

The study aims to evaluate the response of alternative crops and cotton grown under deficit irrigation, based on soil-plant-water relations, photosynthetic traits, physiological traits and final yield.

Materials and Methods

- The study was conducted at New Deal Research Farm, TTU, Lubbock, TX, USA in 2017 growing season.
- The experiment was laid out in a RCBD split-plot design with irrigation levels as main plots and crops as subplots with four replicates.
- The target irrigation amounts for in-season irrigation levels are 51 mm (extreme deficit), 127 mm (severe deficit), 203 mm (moderate deficit) and 279 mm (mild deficit). The crops planted were cotton, guar, pearl millet, safflower, sesame, grain sorghum and sunflower.

(a) (b) (c)

Figure 2. (a) Alternative crops grown with cotton under four deficit irrigation levels, measurement of (b) biomass accumulation, and (c) leaf area index at New Deal Research Farm, TTU in 2017.

- Statistical analysis was performed through GLIMMIX Procedure for Generalized Linear Mixed Models of SAS Enterprise Guide 7.1 software and graphs were generated using SigmaPlot 13.0 software.

Results

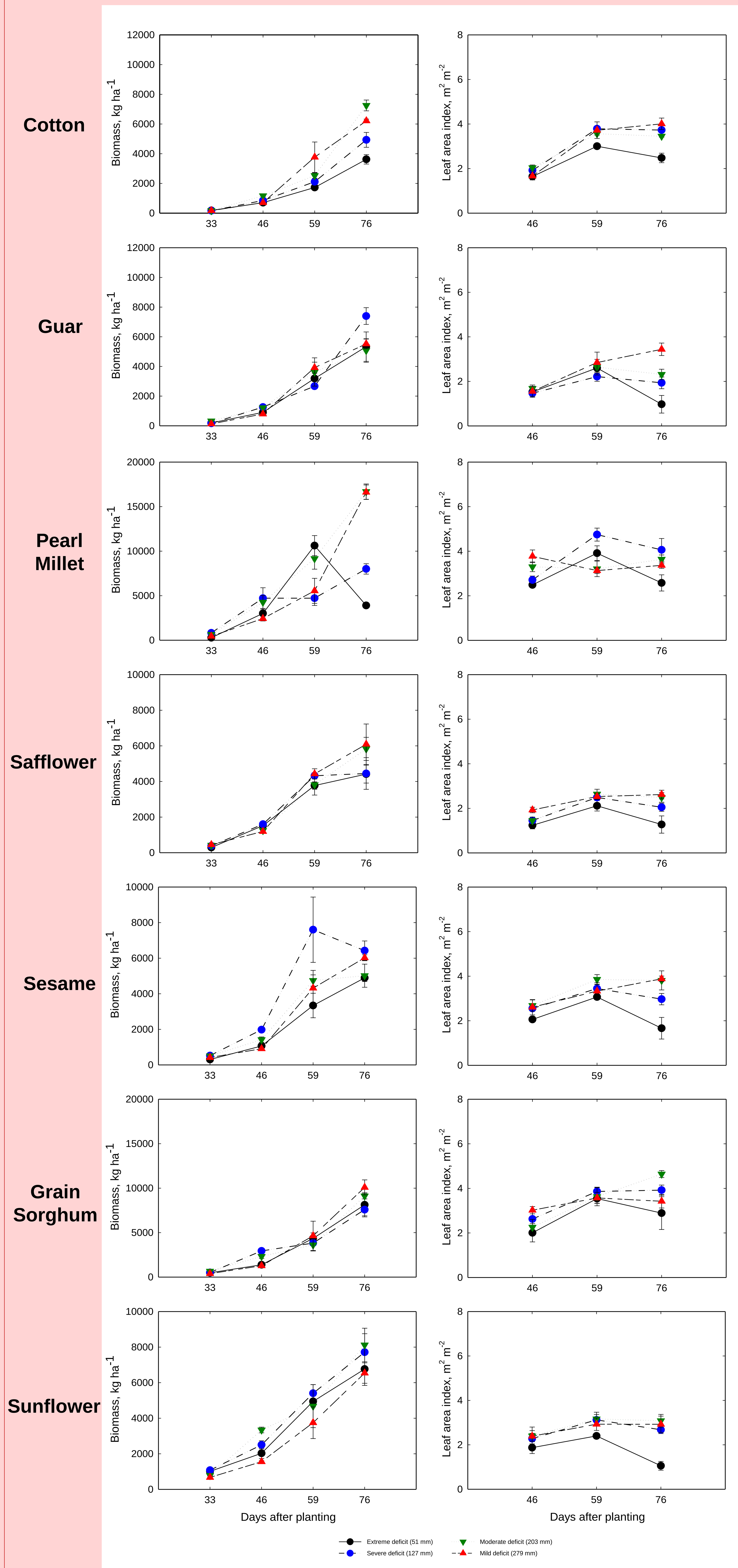

Figure 3. Comparison of biomass accumulation and leaf area index (LAI) of cotton and six alternative crops grown under four deficit irrigation levels in 2017.

Discussion

As shown in Figure 3, there was no siginificant difference in biomass and LAI among treatments for all crops at 46 and 59 DAP, implying that less irrigation applied does not negatively impact plant growth at these stages. The results at 76 DAP are discussed below:

Cotton: There was no significant difference in biomass between moderate and mild deficit treatments. LAI was significantly lower in moderate deficit than mild deficit treatment. At this stage, cotton under moderate deficit responded to stress by allocating its resources to early flowering and boll production.

Guar: There was no significant difference in biomass among treatments. However, extreme, severe, and moderate deficit treatments showed significantly lower LAI than mild deficit treatment. More water stressed conditions resulted in wilting and senescing of leaves as well as early flowering and pod formation of guar.

Pearl Millet: Extreme deficit treatment showed significant decrease in biomass and LAI values after reaching its peak at 59 DAP. Under limited water conditions, millet started heading and senesced earlier to avoid stress. However, moderate and mild deficit treatments showed continuous accumulation of more biomass, possibly due to larger amounts of accessible water made available by deeper roots.

Safflower: No significant difference in biomass was observed among different treatments. However, extreme and severe deficit treatments exhibited lower LAI as a result of wilting and senescence of leaves. Under more water stressed conditions, safflower started flowering and pod formation earlier to avoid stress.

Sesame: There was no significant difference in biomass between severe and mild deficit treatments but plants under severe deficit exhibited lower LAI. There was also no significant difference in biomass among extreme, moderate, and mild deficit treatments but extreme deficit exhibited lowest LAI. Extreme and severe deficit treatments allocated its resources into pod production earlier in the season to avoid water stress.

Grain Sorghum: No significant difference in biomass was observed among treatments. However, extreme deficit exhibited lower LAI than severe deficit treatment. Grain sorghum responded to extreme irrigation deficit by starting grain formation earlier than the other treatments.

Sunflower: All treatments showed no significant difference in biomass, however, extreme deficit treatment showed the lowest LAI. Extreme irrigation deficit elicited earlier flowering and head formation compared to other treatments.

Conclusions

This study demonstrates the growth potential of alternative crops under deficit irrigation conditions. Addition of irrigation to extreme deficit treatment (51 mm) did not significantly improve the crops' vegetative growth in terms of biomass and LAI. At reproductive stage, crops under extreme, severe and moderate deficit treaments responded to stress by maturing rapidly. Growth was also made more efficient possibly by taking advantage of stored soil moisture using deep root systems.

To reinforce these observations, further analysis of collected data on physiological traits such as intercepted PAR, stomatal conductance, relative water content, soil water extraction, leaf water potential will be done in conjunction with yield data by the end of 2017.

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