Morphological changes with Advancement of Sorghum Hybrids

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Introduction

Sorghum grain yield has improved substantially since the mid 1950s, following the deployment of hybrid sorghum production and commercialization (USDA-NASS, 2005) . Based on 61 years of data (1930-1990), Eghball and Power (1995), reported a 50 kg ha^{-1} year^{-1} yield increase in sorghum.

Various factors contributed to this yield increase. Unger and Baumhardt (1999) reported that from 139% of a yield increase, 93 % was a result of increase in amount soil water at planting due to changes in management practices. The other 46% was attributed to improved hybrids. Duvick (1999), also reported that worldwide sorghum production is 19% higher than it would have been without the use of hybrids.

The main objectives of our study were:

(1) To determine the magnitude of yield change in irrigated and rainfed sorghum production in Kansas due to hybrid improvement and change in agronomic practices, and

(2) To determine what aspect of grain sorghum morphology, physiology, and water use might have changed with hybrid improvement and contributed to this yield increase.

Material and Methods

A. Grain sorghum Performance Test

Fifty-two years data from irrigated and rainfed hybrid grain sorghum performance test at five different locations in Kansas were analyzed.

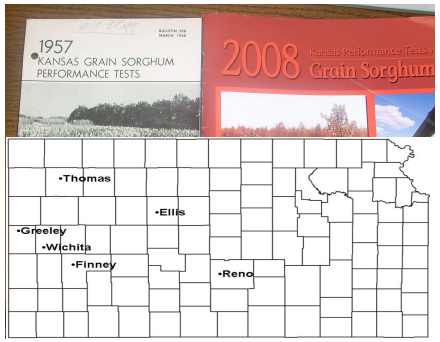

Figure 1. Grain sorghum performance test report booklets and locations selected for this study.

B. Greenhouse study

A greenhouse experiment was conducted for two years (2007 and 2008) on five selected hybrids; P848/RS610, P828/P833, P8585, P8385, and P85G46 which were released in periods of 1954-1964, 1964-1974, 1974-1984, 1984-1994, and 1994 2005, respectively. The hybrids were studied under pre-, and post-flowering drought stress, and optimal moisture conditions.

Major Results

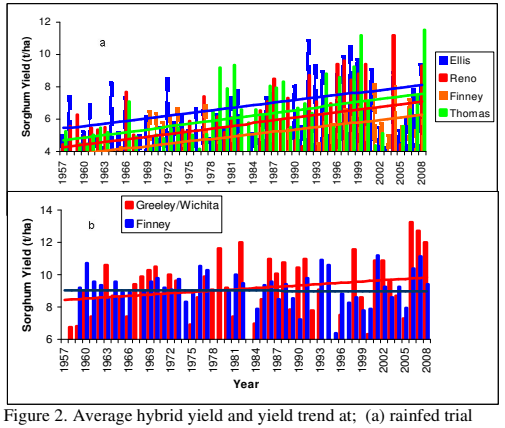

Figure 2. Average hybrid yield and yield trend at; (a) rainfed trial sites and (b) irrigated trial sites, from 1957-2008.

Table 1. Pearson correlation coefficients (R) and probabilities for average yield and year (1957-2008) against monthly rainfall and temperature

	Total monthly rainfall				
	May	June	July	August	September
R for yield	0.07	0.03	0.36	0.19	0.02
Prob > r	0.34	0.62	<0.01	<0.01	0.75
R for year	-0.01	-0.13	-0.04	0.14	-0.20
Prob > r	0.97	0.06	0.53	0.05	<0.01
	Mean monthly temperature				
	May	June	July	August	September
R for yield	0.04	-0.01	-0.13	-0.15	0.03
Prob > r	0.52	0.88	0.07	0.03	0.68
R for year	-0.01	-0.00	0.01	-0.03	0.07
Prob > r	0.86	0.90	0.88	0.66	0.30

Result from Grain Sorghum Performance Test:

- Sorghum yield increased in all rainfed trial sites (~50 kg ha^{-1} yr^{-1}) from 1957 to 2008 (Fig. 2a).
- Average sorghum yield was nearly constant at irrigated trial sites (Greeley/Wichita and Finney counties) over the past 52 years (Fig. 2b).
- Rainfall and temperature did not show significant change over the same period at these sites (Table 1). This shows that the yield increase in the rainfed trials was not due to changes in rainfall or temperature.
- Agronomic practices such as: planting date, fertilizer use, and planting density have changed within these years (data not presented). None of them, however, were found to contribute to changes in sorghum yields. Hybrid advancement and increased nitrogen fertilizer application, perhaps due to mitigating drought induced nutrient deficiency, were responsible for changes under rainfed production.

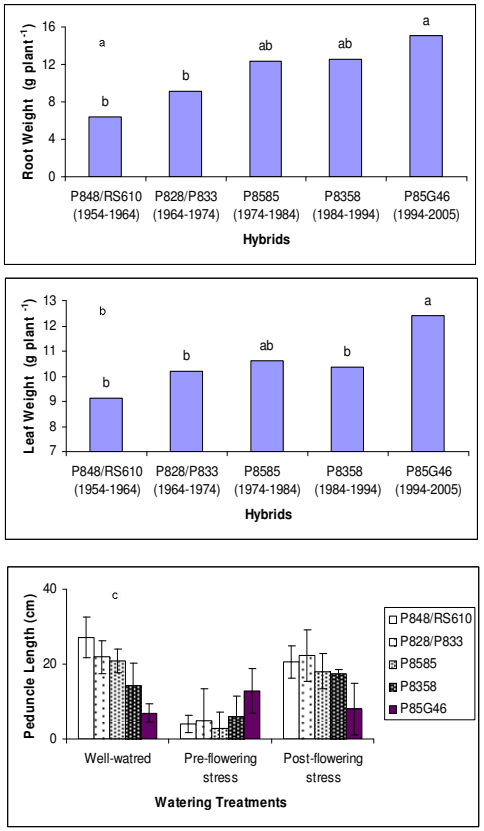

Figure 3. (a) Root dry weight, (b) Leaf dry weight, and (c) peduncle length, of the hybrids tested.

Result from Greenhouse study

- Water stress periods decreased water use in all hybrids. When water is on demand (in well-watered treatment), recent hybrids used more water than the old hybrids. Overall, recent hybrids had the highest total water use (data not presented).
- Root biomass showed a consistent increase with advancement of hybrids (Fig 3a).
- Leaf biomass was highest for the newest hybrid (Fig 3b).
- In the well-watered treatment, peduncle length decreased with advancement of hybrids (Fig 3c).
- There was no relationship obtained between the physiological measures (leaf temperature, stomatal conductance, and photosynthesis) with advancement of hybrids (data not presented).

Conclusions

Grain sorghum performance test results indicates that the yield focus of sorghum hybrid development was mainly effective in rainfed sorghum production, perhaps due to long periods of drought tolerance focused research, which might resulted in hybrids with better drought tolerance characteristics.

The greenhouse data indicates that yield changes with hybrid improvement have come through deliberate or inadvertent selection of hybrids with improved morphological characteristics, mainly higher root and leaf biomass and a shorter peduncle to panicle length, which might have enabled better use of resources.

Testing in multiple years and locations in more rainfed (dryland) areas than irrigated areas might have favored continuous improvement of hybrids that have better root biomass to access more available water and nutrient resource around.

To improve sorghum genetic yield potential in irrigated areas, breeding programs should intensify their effort on hybrid selection focused for these resource rich environments as well.

Reference

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Acknowledgment

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