Studies on sorghum minicore germplasm and breeding lines to identify potential sources for abiotic and biotic stressors

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Introduction

- Increased water scarcity and climate change coupled with increased food and energy demands necessitates identifying potential sources to develop high yielding sorghum hybrids under abiotic and biotic stress conditions. Drought is consistently the most limiting abiotic stress factor to crop productivity around the world (Boyer, 1982). Fusarium stalk rot (*Fusarium thapsinum*) and charcoal rot (*Macrophomina phaseolina*) diseases are the high priority grain sorghum fungal diseases in world wide (Tarr, 1962). The environmental conditions favor the disease development leading to lodging and ultimately yield loss. In Kansas state alone, stalk rot results in annual economic loss of $15 million per year (Tesso et al., 2004).

- Even though the world collection of sorghum accession is ~44,773, currently maintained and used in breeding programs is very low (~3%). Therefore, continuous exploitation of available genetic resources to identify and introgress the valuable traits into adapted breeding lines for biotic and abotic stress tolerance is of paramount important to improve the yield performance (Resenow and Dahlberg, 2000).

Objectives

- Evaluate sorghum minicore germplasm for physiological and disease traits associated with abiotic (drought) and biotic (stalk rot and charcoal rot) stresses.
- Identify drought and disease tolerant lines to utilize it for future breeding programs.
- *Identify parental lines with extreme performance to M. phaseolina and F. thapsinum infection to develop mapping population separately for each pathogen*

Materials and Methods

Genotypes:
140 sorghum genotypes (84 photo-insensitive minicore lines from ICRISAT [India], 50 promising breeding lines + 6 checks TX7000R, TX7078R, TX3042B, SC399R, SC599R, B35).

Environment:
Two (Irrigated and dryland) at Ag. Res. Center, Hays, KS IN 20in2011.

Design:
RCBD with two replication.

Treatment:
Plant inoculated with *F. thapsinum, M. phaseolina*, and water, 10 days after flowering using standard inoculation procedures at the rate of 1 ml plant^{-1} between the bottom-most node and brace node (Fig 1).

Traits measured:
i. Leaf canopy temperature, chlorophyll content, photosynthetic efficiency (Fv/Fm) starting anthesis (Fig 2),
ii. Lesion length (28 days after inoculation (Fig 3)
iii. Plant height, grain yield, and harvest index.

Data analysis:
i. Analysis of variance (PROC GLM procedure of SAS).
ii. Pearson correlation coefficients (SAS).
iii. Principle component analysis (PCA) using XLStat.

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Fig 1. Inoculation

Fig 2. Dark adapted measurement of Fv/Fm

Fusarium stalk rot — Charcoal rot

Fig 3. Lesion length measurements from the inoculated plants

Experimental Results

Table 1: Mean square and significant level for physiological traits measured during anthesis and flowering in sorghum minicore collection during 2011 at Hays, Kansas.

Source	df	SPAD readings			Fv/Fm		Leaf temperature		Plant height
		59DAP	76DAP	103 DAP	67DAP	83DAP	61DAP	81DAP	
Environment	1	572.52	48.79	41151.4*	0.33	0.26	2420.76	9163.54	319353**
Block(Env)	2	110.35	567.11	1946.1***	0.03	0.27	2582.44	1866.86	1623
Entry	139	242.26***	379.64***	229.6***	0.005***	0.003***	84.68	12.62***	13324***
Env*Entry	137	135.40***	148.64***	155.5***	0.005***	0.003***	83.55	11.87***	1631**
Error	1358(272¶)	36.67	55.97	60.2409	0.002	0.002	78.71	5.45	1143

¶ Error df for plant height; * $P < 0.05$, ** $P < 0.01$and *** $P < 0.001$significance level

Table 2. Mean squares and significance levels (*p*) from ANOVA over two environments at Hays, Kansas, for lesion length and grain yield related to stalk rot and charcoal rot in sorghum minicore collection during 2011.

		Lesion length		Grain yield		
Source	df	Stalk rot	Charcoal rot	Stalk rot	Charcoal rot	Control plants
Environment	1	743.36*	2166.67	3577	20431	4511**
Block(Env)	2	11.00	148.20*	480	85697	31
Entry	130	234.59***	241.39***	741***	37807	454***
Env*Entry	88	94.79***	134.61***	373***	59340	242
Error	674(666¶)	50.15	46.76	202	67489	186

¶ Error df for Charcoal rot; * $P < 0.05$, ** $P < 0.01$and *** $P < 0.001$significance level

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Table 3. Eigen values and proportion of total variability among the genotypes as explained by first 14 principle components as well as component loading for physiological and disease related traits to140 sorghum genotypes

Principle component variability				Component loading			
PC	Eigen value	Variability (%)	Cumulative (%)	Variable /factor	PC1 λ = 23.7%	PC2 λ = 15.4%	PC3 λ = 11.6%
1	3.56	23.73	23.73	spad1	0.57	0.17	0.02
2	2.32	15.44	39.17	spad2	0.76	0.19	0.25
3	1.75	11.65	50.82	spad3	0.74	0.16	0.03
4	1.19	7.95	58.77	FvFm1	0.26	-0.18	0.45
5	1.07	7.14	65.91	FvFm2	0.46	-0.22	0.32
6	0.87	5.78	71.69	LeafTemp1	0.06	-0.19	-0.49
7	0.80	5.33	77.02	LeafTemp2	0.07	0.21	-0.32
8	0.68	4.52	81.54	LLMacro	-0.27	0.02	0.59
9	0.59	3.94	85.48	LLFus	-0.40	0.08	0.62
10	0.49	3.25	88.73	GYMacro	-0.10	0.83	0.01
11	0.45	2.98	91.71	GYFus	-0.14	0.85	0.03
12	0.40	2.66	94.37	GYWater	-0.15	0.75	-0.05
13	0.34	2.28	96.65	plht	-0.69	0.03	0.46
14	0.27	1.77	98.42	HI	0.75	0.27	0.09
15	0.24	1.58	100.00	50%FLDays	-0.71	0.08	-0.30

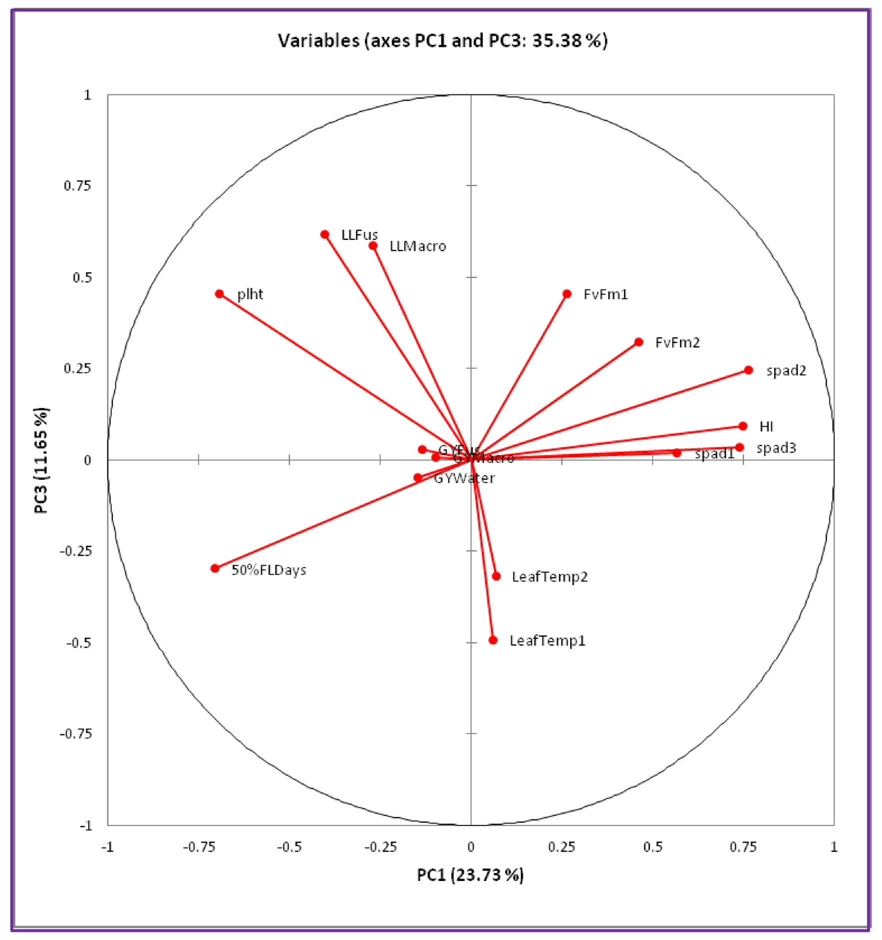

Fig 4.Two dimensional plot of PC1 vs PC3 for physiological and disease related traits in sorghum.

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Summary

• Wide variability was observed between genotypes for physiological traits , *Fusarium* stalk rot and charcoal rot in sorghum germplam (Table 1 & 2) studied.

•Genotypes IS 29233, PI 565174R, IS 2864, 1790ER, SC599R and SC35R expressed high degree of resistance to both *Fusarium* stalk rot and charcoal rot diseases.

• Lesion length and grain yield were negatively correlated with SPAD, Fv/Fm, and harvest index (Fig 4 and Table 3) indicating the higher the disease infection results in lower photosynthesis and thus reduction in grain yield.

• Genotypes IS28451, PI26737R, PI264451, IS19262 and PI533946, B35, TX7000R and TX399B were identified for increased photosynthetic efficiency (Fv/Fm) with high chlorophyll content.

•Genotypes PI267109R, PI576380R, IS29326, IS2205, IS26701, IS29304,TX7000R, TX7078R, and B35B had higher canopy temperature without decrease in harvest index suggesting lower water use and greater tolerance to limited moisture and high temperature.