Response of Sorghum Genotypes to Charcoal Rot and *Fusarium* Infection Under Three Nitrogen Fertilization Regimes

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INTRODUCTION

Charcoal rot and *Fusarium* stalk rot are important diseases of grain sorghum. Besides their direct effect on yield, they induce lodging that causes further reduction in yield and quality of grains and increase problems with harvest. Previous studies associate that stalk rot incidence with post flowering drought response of genotypes which may be influenced by nitrogen nutrition.

The objective of this study was to asses the reaction of sorghum genotypes of variable stay green properties to infection by *Macrophomina phaseolina* and *Fusarium thapsinum* under three levels of nitrogen.

MATERIALS AND METHODS

The experiment was conducted in 2010 and 2011 seasons at Manhattan and Ottawa, KS. The experimental design was a randomized complete block design with a split-plot arrangement. Three N rates: 0 kg ha^{-1} (control), 45 kg ha^{-1} (half recommended rate) and 90 kg ha^{-1} (optimum rate) were assigned to the main plots and 12 sorghum genotypes, six hybrids and another six inbreds, were assigned to the sub-plot. The nitrogen fertilizer (urea, 46% N) was hand broadcast 10 to 14 days after emergence. The test genotypes constitute varying genetic backgrounds of known pre and post-flowering drought tolerance characteristics (Table 1). At flowering, 6 uniform plants in a plot were tagged with plastic tapes of two district colors. On 14th day after flowering, three of the tagged plants were inoculated with *Macrophomina phaseolina* and the remaining three with *Fusarium thapsinum*. For *M. phaseolina*, infected toothpicks were used to deliver the inoculum in to the piths of the basal stalks. While for *F. thapsinum*, the idico filler plug gun with a modified needle was used to deliver approximately one ml of liquid inoculum containing 50,000 conidia. In both cases, the inoculum were delivered into the stalk about 10cm the ground level (Fig.1a,b). On 28 day after inoculation, infected plants were harvested and rated for disease severity by measuring the length of necrotic lesion (cm) and by determining the number of nodes contained within the lesion (Fig 1c). Tissue nitrogen was determined using a modified semi-micro-Kjeldahl method (Lowther 1980) from aerial portions of plants sampled at flowering and physiological maturity. Leaf greenness was scored from 10 fully expanded leaves using a SPAD meter. Data were subjected to statistical analysis with the general linear Model in SAS (SAS, 2010).

Table 1. Characteristics and description of genotypes used in the study.

Lines	Reaction to stalk rot pathogens	Hybrids	Drought reaction
Tx430	Non Stay green	26506	PreFDS, PostFDR
SC599	R (MP & FT)	CSR1114 x R45	PostFDR
B35	R (MP)		PreFDR, PostFDR
SC35	R (MP)	95207	PreFDR,PostFDS
Tx2783	unknown	23012	PreFDR, PostFDR
Tx7000	S (MP)	Tx3042 x Tx2737	PostFDS

PreFDS:Preflowering drought susceptible, PostFDS:Postflowering drought tolerant, PreFDR: Preflowering drought tolerant; PostFDR: Preflowering drought tolerant; R-resistant; S-susceptible; MP-*Macrophomina phaseolina*; *FT-Fusarium thapsinum*

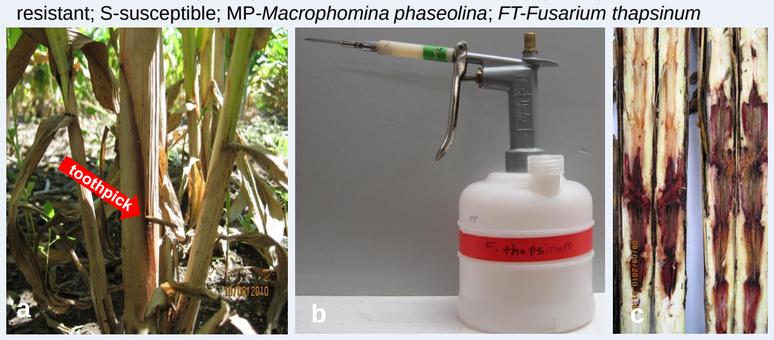

Fig 1: Illustration of field inoculation and disease scoring procedure: tooth pick method (a) for *M. phaseolina*, and liquid inoculation with modified plug gun (b) for *F. thapsinum* and necrotic lesions (c) from infected plants.

RESULTS AND DISCUSSION

Table 2. Mean squares from analysis of variance for sorghum hybrids inoculated with *Macromophina phaseolina* and *Fusarium thapsinum* across four location-years.

		Macrophomina phaseolina		*Fusarium thapsinum*	
Source	df	lesion length (cm)	Number of nodes crossed	lesion length (cm)	Number of nodes crossed
Environment (E)	3	989.3**	128.3**	985.1**	106.8**
Nitrogen (N)	2	68.7**	8.1**	30.1	0.1
Genotype (G)	5	91.4**	9.2**	101.5**	8.4**
G x N	10	43.7*	2.7*	19.5	3.3**
G x E	15	41.0*	2.5*	46.7**	6.2**
Error	240				

*,** statistically significant at P ≤ 0.05 and P ≤ 0.01, respectively.

Table 3. Mean squares from analysis of variance for sorghum lines inoculated with *Macromophina phaseolina* and *Fusarium thapsinum* across four location-years.

		Macrophomina phaseolina		*Fusarium thapsinum*	
Source	df	lesion length (cm)	Number of nodes crossed	lesion length (cm)	Number of nodes crossed
Environment (E)	3	198.5**	28.9**	206.9**	28.3**
Nitrogen (N)	2	3.1	0.3	1.7	0.2
Genotype (G)	5	541.8**	44.0**	498.3**	41.6**
G x N	10	7.9	1.24	4.8	0.7
G x E	15	86.3**	9.22**	25.8**	2.6**
Error	240				

*,** statistically significant at P ≤ 0.05 and P ≤ 0.01, respectively.

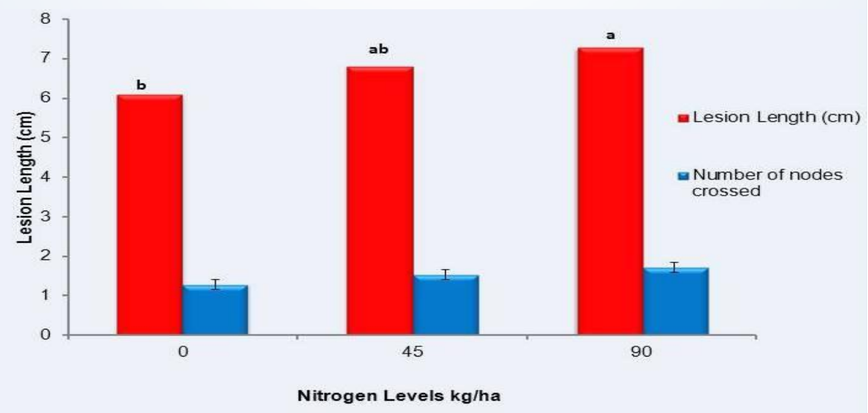

Fig 2: Mean lesion lengths and number of nodes crossed of sorghum hybrids as affected by Nitrogen levels following basal inoculation with *Macrophomina phaseolina.*

Table 4: Mean performance of sorghum genotypes averaged over two location-years and levels of nitrogen fertilizer application.

	Lesion length (cm)					
Lines	*M. phaseolina*	*F. thapsinum*	Total N flowering (g/plant)	Total N Maturity (g/plant)	SPAD Flowering	SPAD Maturity
Tx430	**3.1**	**4.0**	**0.86**	**0.37**	**53.0**	**44.1**
SC599	**2.9**	**3.9**	**0.81**	**0.30**	**47.8**	**40.5**
B35	**4.0**	**6.0**	**0.89**	**0.45**	**53.8**	**45.5**
SC35	**6.5**	**6.5**	**1.07**	**0.49**	**51.9**	**43.8**
Tx2783	**4.9**	**5.3**	**0.92**	**0.35**	**49.0**	**41.3**
Tx7000	**8.9**	**9.8**	**0.89**	**0.34**	**47.9**	**40.6**
Mean	**5.1**	**5.9**	**0.91**	**0.38**	**50.6**	**42.6**
LSD(0.05)	**1.2**	**1.1**	**0.13**	**0.09**	**2.15**	**2.55**
Hybrids						
26506	**6.8**	**8.4**	**0.81**	**0.32**	**51.5**	**42.7**
CSR1114 x R45	**5.5**	**6.8**	**0.82**	**0.38**	**51.4**	**51.1**
99480	**6.2**	**7.4**	**0.89**	**0.32**	**48.2**	**40.1**
95207	**6.6**	**6.3**	**0.75**	**0.32**	**49.2**	**41.2**
23012	**7.2**	**6.8**	**0.70**	**0.27**	**48.4**	**39.6**
Tx3042 x Tx2737	**8.2**	**5.6**	**0.83**	**0.27**	**51.0**	**42.7**
Mean	**6.7**	**6.9**	**0.80**	**0.32**	**49.9**	**42.9**
LSD(0.05)	**1.7**	**1.3**	**0.09**	**0.07**	**2.15**	**13.9**

- Reaction to stalk rot infection among test entries was significantly different for both pathogen groups (Tables 1 and 2)
- Disease severity was generally higher among hybrid entries than inbred genotypes and this was consistent with previous findings (Tesso et al., 2005)
- There was no significant differences between levels of nitrogen except for hybrids inoculated with *Macrophomina phaseolina* where higher levels of nitrogen fertilizer appear to have increased disease severity (Table 2 and Fig 2)
- Genotypes with higher total leaf nitrogen tended to be more resistant to both pathogens
- Likewise, genotypes with stay green trait (high SPAD scores) were more resistant to both stalk rot pathogens. This agrees with previous findings where severity of stalk rot diseases were shown to have strong correlation with severity of drought (Setharama et al., 1987)
- On the other hand, few genotypes with moderate to low leaf nitrogen and low SPAD scores also expressed high degree of resistance to both pathogens indicating additional factors may be responsible for genotypic response to stalk rot infection
- Inbred line SC599 was outstanding in its reaction to both pathogens followed by Tx430. Whereas, Tx7000 was most susceptible to both *M. phaseolina* and *F. thapsinum*
- Hybrids CSR1114 x R45 (post flowering drought tolerant) and Tx3042 x Tx2737 had the lowest lesion length when inoculated with *M. phaseolina* and *F. thapsinum,* respectively
- While some of the entries expressed more or less similar pattern of reaction to both *M. phaseolina* and *F. thapsinum*, many of the genotypes had variable reaction to the two pathogens indicating that resistance to the two pathogens is likely under different genetic control

CONCLUSIONS

- High levels of tissue nitrogen and increased green leaf area appear to be positively correlated with resistance to stalk rot infection
- The presence of non-stay green/low tissue N genotypes with high levels of resistance is a significant complement to the well characterized stay-green associated resistance and may provide opportunity for gene pyramiding
- The evidently strong negative correlation between yield potential and stalk rot resistance presents challenges for breeding high yielding hybrids with resistance to stalk rot diseases

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ACKNOWLEDGEMENTS

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