Table 1. Chemical analysis of sorghum ovaries and midge damage.

Cultivar	Total sugars (mg g-1)	Reducing sugars (mg g-1)	Non-reducing sugars (mg g-1)	Amino acids (mg g-1)	Phenol (mg g-1)	Tannin (mg g-1)	Midge damage (%)
SB 101(S)	12.0	4.16	7.80	1.47	0.37	9.4	49
SB 401(S)	15.6	5.06	10.48	1.19	1.04	27.0	67
DMS 1(S)	15.0	4.21	10.82	0.99	0.87	21.0	56
DSV 1(S)	15.7	5.04	10.62	1.43	0.65	13.5	73
D 340(S)	14.4	5.17	9.25	1.36	0.44	8.4	82
X_S	14.5	4.73	9.79	1.29	0.67	15.9	65
IS 18698(R)	5.8	2.05	3.76	0.70	1.23	37.0	20
TAM 2566(R)	7.9	3.00	4.89	0.80	1.27	28.6	21
DJ 6514(R)	8.8	2.88	5.91	0.85	0.84	21.3	18
PM 14358-7(R)	6.5	2.67	3.85	0.80	0.96	28.8	25
PM 14410-1(R)	7.6	2.85	4.72	0.76	0.91	32.4	27
ICSV 745(R)	8.6	3.35	5.25	0.76	0.76	41.7	20
PM 7061(R)	6.5	2.24	4.25	0.65	1.04	33.6	22
PM 7068(R)	7.2	2.56	4.60	0.60	0.97	26.6	26
X_R	7.4	2.70	4.65	0.74	1.00	31.3	22
SEM	±0.1	±0.03	±0.09	±0.01	±0.04	±1.34	±2
CD (5%)	0.3	0.06	0.25	0.04	0.11	3.82	4

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Correlation Studies between Plant Height and Days to Flowering to Shoot Fly (*Atherigona soccata* Rond.) Resistance in Glossy and Nonglossy Sorghum Lines

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Correlation studies between adult plant characters (plant height, days to flower, and shoot fly resistance parameters) indicate that days to flower played a vital role in reducing oviposition, but tall and late flowering glossy sorghum genotypes seemed favorable in decreasing shoot fly damage and advantageous in improving shoot fly resistance. Shoot fly is a serious pest-causing sorghum grain yield reduction in semi-arid tropics of the world. Several researchers have shown that glossy sorghum genotypes with light yellow green and shining leaf surface at early seedling stage are resistant to shoot fly, compared to non-glossy lines having dark green leaves (Maiti and Bidinger, 1979; Maiti et al., 1984). The levels of shoot fly resistance depend on the trichome density and the intensity of glossiness (Maiti and Bidinger, 1979; Maiti and Gibson, 1983; Gibson and Maiti, 1983; and Omori et al. 1988). In addition, glossy lines also showed multiple resistance to several biotic and abiotic stress factors (Maiti, 1986). Recent studies have established that the presence of glossiness, trichomes and seedling vigor contributed substantially in reducing shoot fly damage (Maiti, Taneja, Rao, and Nwanze, 1992 - unpublished data), but no information is available on the relationship between adult plant characters and shoot fly resistance. The present study emphasizes this aspect of research. Five hundred and twenty sorghum lines varying in the intensity of leaf surface glossiness at the seedling stage have been used to study the relationship of plant height and days to flower on shoot fly incidence. The data on shoot fly resistance parameters [% plants with shoot fly eggs (% PE)] and % plants with dead hearts and the plant characters, namely plant height and days to flower have been collected from the records of the entomology section and Genetic Resource Unit, respectively at ICRISAT. Standard statistical techniques are used to quantify the relationship among these characters for drawing meaningful conclusions. The correlations among plant height (PH), days to flowering (DF), percent plants with shoot fly eggs (% PE) and percent plants with dead hearts (% PD), caused by shoot fly have been worked out among glossy and non-glossy lines and given in Tables 1 and 2.

Table 1. Correlation matrix among morphological and shoot fly resistance parameters in glossy lines.

Characters	DF	PH	PE
PH	0.1101*		
PE%	-0.1985**	0.034	
PD%	-0.2271**	-0.0671*	0.8849**

PH: Plant height, DF: Days to flowering, PE: Per cent plants with shoot fly eggs, PD: Per cent plants with deadhearts
*, ** Significant at 5% and 1% levels, respectively.

Table 2. Correlation matrix among morphological and shoot fly resistance parameters in non-glossy lines.

Characters	DF	PH	PE%
PH	0.1056		
PE%	-0.2784	0.0622	
PD%	-0.1781	0.0576	0.8862**

** Significant at 1% level.

The results showed that days to flower had negative and significant association with percent plants with eggs (% PE) and percent plants with dead hearts (% PD) among the glossy lines. These values are not significant in the case of non-glossy lines, but they had similar effects in direction. This indicates that genotypes with high gloss intensity and late maturity are more advantageous in decreasing shoot fly susceptibility. The relationship between plant height and shoot fly resistance parameters (% PE & PD) were found negligible in both glossy and non-glossy groups. In order to estimate the extent of the effects of plant height and days to flower on shoot fly incidence parameters, the regression equations have been fitted among glossy and non-glossy genotypes, and the respective response coefficients are given in Table 3. Among the glossy group, days to flower had significant effect on % PE; whereas, plant height and days to flower and their interactions contributed substantially to shoot fly damage. The relationships among these traits were found negatively linear in the case of non-glossy lines. Therefore, among the adult plant characters, plant height played a role on egg nonpreference and shoot fly damage. In addition to days to flower, its interaction with plant height contributed substantially but positively linear to damage percent. The results indicate that the effect of both plant height and days to flower on shoot fly parameters are highly dependent among the genotypes with the glossy trait.

Table 3. Response coefficients of plant height (PH) and days to flowering (DF) in different functions.

Functions	PH	DF	(PH × DF)
Glossy lines			
PE%/(PH,DF)	0.0097	-0.3416**	
PD%/PH,DF, (PH × DF)	-0.177	-0.868**	0.0024
PD%/(PH, DF)	-0.0155	-0.3603**	
PD%/PH, DF,(PH × DF)	-0.303**	-1.169**	0.0036**
Non-glossy lines			
PE%/(PH,DF)	0.0251	-0.401	
PE%/(PH, DF,PH × DF)	0.809*	1.630	-0.0105*
PD%/(PH,DF)	0.0221	-0.273	
PD%/(PH, DF,PH × DF)	0.908**	2.024*	-0.00118**

*, **Significant at 5% and 1% levels, respectively.

An interdependency between shoot fly resistance levels, plant height, and days to flower among glossy lines has been tested using χ^2 statistics, and the results are shown in Table 4, where ovipositional preference (PE%) was independent of plant height; and shoot fly damage was found to be significantly dependent on plant height. Similarly, PE% and PD% were highly dependent on days to flower.

Table 4. Test of independence between shoot fly resistant levels, plant height and days to flowering among glossy lines.

Comparison	df	χ^2 - value
Plant height vs % PE	4	4.59
Plant height vs % PD	4	9.74*
Days to flowering vs % PE	4	22.82**
Days to flowering vs % PD	4	30.18**

In order to better understand the contribution of adult plant height and days to flower to shoot fly resistance among the glossy lines, these characters are further grouped into three plant height classes, i.e., dwarf (less than 150 cm), medium (150-250 cm), and tall (more than 250 cm), and three flowering groups such as early flowering (less than 70 days), intermediate (70-90 days), and late (more than 90 days). From this analysis, days to flower played an important role on oviposition preference, but not on plant height. In the case of damage percent, the selection of tall and late maturity genotypes seems favorable in reducing the shoot fly incidence. This needs further confirmation with a set of isogenic lines.

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Sorghum Midge Efficacy of Infestation on Resistant Sorghum Lines

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Harris (1985) suggested that sorghum midge resistant sorghum cultivars offer the best hope of controlling the sorghum midge on a long-term basis. An adequate perception of the interactions between sorghum and sorghum midge is required if resistance to sorghum midge is to be used as a component of a pest management program. The objective of this paper is to present results that may suggest meaningful interactions between the sorghum midge and sorghum lines resistant to the damage caused by the insect. Two sorghum midge resistant lines (Tx2782 and Tx2767), and one susceptible (Tx430) were planted 14 May, 1993 at the Texas A&M Research Farm in Burleson Co. Texas. Starting two days before anthesis, and continuing until physiological grain maturity, the sorghum plots were sampled to estimate abundance of immature sorghum midge per spikelet; two spikelets per plant were randomly collected from 48 plants in each plot every other day. Spikelets were dissected under a microscope to record presence of immature stages of the sorghum midge. Abundance of sorghum midge eggs was significantly higher in the sorghum midge susceptible line Tx430, which contained 88% of the eggs found 24 h after maximum abundance of midge adults on each line occurred. Besides their scarcity, many of the eggs laid on resistant lines were either placed in unfavorable conditions for their development, or where the eggs do not represent potential damage to the crop (Fig. 1). Sorghum midge eggs laid outside of the spikelet are likely to die due to dehydration. Young sorghum midges that hatch