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Field Screening of Sorghum [Sorghum bicolor (L.) Moench] Inbred Lines for Resistance to Striga [Striga hermonthica (Del.)] in East Hararghe, Ethiopia

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Abstract
Drought and the obligate *Striga* root parasite are two of the most important constraints to sorghum production in the northern and north eastern parts of Ethiopia. *This study assessed the field reaction of selected advanced lines under Striga hermonthica infestation condition. Twenty-two sorghum genotypes with two resistant checks (Gobiye and SRN-39) and one susceptible check (Teshale) were evaluated under Striga hot spot area at Fadis Agricultural Research Center, Boko research station (Ethiopia) in the 2016 season using a 5x5 triple lattice design. During the field experiment, 11 parameters were measured among which Striga count emerged on each genotype was the indicator of resistance genotypes. Genotypes differed significantly in all measured parameters in their reactions to Striga. Genotypes 2006 MW 6044, ETSC 300003, ETSC 300081, 05 MW 6019, and ETSC 300080 showed Striga resistance in the field. Thus, these genotypes were the most promising sources of resistance to S. hermonthica. From field experiments, it could be suggested that genetic variability for resistance and tolerance is available in a range of genotypes, which could be used for future breeding and production in Striga infested areas.*
Keywords: genotypes, germination stimulant, parasitic weed, resistant, screening techniques
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INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important grain crop globally after maize, wheat, rice, and barley (FAO, 2015). It is the most important staple food crop for more than 500 million people in Africa, Asia and Latin America, particularly in semi-arid tropical regions where drought is the major limitation to food production (*Ejeta*, 2005). Under favorable conditions, sorghum has a higher yield potential than other major cereals, such as rice (*Oryza sativa*), wheat (*Triticum* spp.) and maize (*Zea mays*) (Reddy *et al.,* 2012).

In Ethiopia, sorghum is the most important cereal crop, particularly in lowland areas where rainfall is unreliable and in places where crop failures are common due to recurrent drought. The crop is one of the major food cereals, like tef, wheat, maize and barley (CSA, 2015). It ranks second after maize in total production, third after wheat and maize in productivity per hectare, and after tef and maize in area cultivated. Sorghum is cultivated in almost all regions, covering a total land area of 1.86 million hectares and grown mainly in dry-lands and semi-arid areas of Ethiopia where drought and poor harvests are common. It is considered as the principal crop providing means of survival (CSA, 2016).

Currently, sorghum is produced by 4.96 million householders with production giving the potential average grain yield of 2.3 tons per-hectare (CSA, 2016). However, various biotic and a biotic factors contributed to the low productivity of sorghum. Among the biotic factors, weed, mainly *Striga* is the most important cause of yield loss in most regions of Ethiopia (Rebeka *et al*., 2014. Hussien (2006) stated that *Striga* species have become the most common parasitic weeds in sorghum producing areas of eastern Ethiopia. In Ethiopia, losses of 65-100% are common in heavily infested fields (*Ejeta et al.,* 2002). Its effect depends on the crop genotype, degree of infestation, rainfall pattern, and fertility of the soil (Aly, 2007).

Striga, once introduced into the field, will remain as a serious challenge for eradication due to its ability of producing large number of seeds per plant. *Striga* seeds require a period of pre-treatment 'conditioning' in a moist warm environment for 2–14 days before they have the potential to germinate (Logan and Stewart, 1991). Germination occurs in response to an exogenous stimulant. In nature, the stimulant is exuded from the roots of host and some non-host plants. So far, three different types of compounds have been identified as germination stimulants for root parasitic plants; dihydroquinones, sesquiterpene lactones and Strigo-lactones (SLs) (Bouwmeester *et al.,* 2003).

Effective, affordable, and sustainable management options are needed to enhance small-scale sorghum productivity in areas where the parasite occurs. The use of resistant cultivars is a most robust and effective approach to management parasitic weeds. Host-plant resistance in adapted, productive cultivars is a central component of integrated Striga management. The uses of resistant varieties have been promoted as the most

affordable, effective, and environmentally sound method for the management of Striga. This has been demonstrated in multi-location field tests conducted in Ethiopia and Tanzania (Tesfaye et al., 2007). In Ethiopia there is significant genetic variation for Striga resistance in sorghum (Tokuma, 2016). Precise and reliable screening techniques are indispensable in order to select *Striga* resistant lines through breeding (Vasudeva, 1985). The presence of individual mechanisms conferring resistance to *Striga* may be examined in the laboratory, whereas complex resistance must be assessed under field conditions (Haussmann *et al*., 2000).

Ethiopia, so far about four varieties have been released for production in *Striga* infested areas of the country. However, with the diversity of sorghum growing environments and the expanding effect of *Striga* on sorghum production, developing additional varieties that have high yield potential and *Striga* resistance is one of the priorities. Therefore, the present study aimed to identify the Striga resistant/tolerant sorghum inbred lines under field conditions.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at the Fadis Agricultural Research Center (FARC) of Fadis research site in East Hararghe, Ethiopia. This area, under rain-fed conditions, was used from July 2016 to November 2016. It lies between 8°22' and 9°14' North latitude, and 42°02' and 42°19' East longitude. Fadis is located at 1700 m a.s.l. with a mean annual rainfall of 804 mm; the annual minimum and maximum ambient temperature is 20–25 ºC. and 30–35 ºC., respectively (Samuel *et al.,* 2013).

The seasonal temperature and total amount of rainfall in the study area were major constraints for *Striga* plants to emerge during 2016. In the 2016 cropping season, almost no satisfactory rain occurred during the critical growth stage (phonology) of the sorghum crop (*i.e*. flowering, heading, and physiological maturity stages) at which the *Striga* plants were expected to emerge. The crop headed in August with 56.8 mm of rainfall. The total rainfall during the year (2016) was (72.5 mm), which is far less than the average rain fall of the last six (2010-2015) years (129.3mm) (Table 1), and this made the *Striga* plants to enter into secondary dormancy. Rainfall distribution was also erratic, particularly during the flowering and physiological maturity of the crop (Table 1). As a result, *Striga* emergence was few in number, causing low infestation level on the crop. *Striga* seeds normally require a period of pre-treatment 'conditioning' in a moist warm environment for 2–14 days before they have the potential to germinate (Logan and Stewart 1991).

Table 1: Monthly rainfall and temperature of 2010-2015 and 2016 growing seasons at Fadis

	2010-2015 Meteorological data			**2016 Meteorological Data**		
	Rainfall (mm)	**Temperature (ºC)**		**Rainfall (mm)**	**Temperature (ºC)**	
Month		**Min.**	**Max.**		**Minimum**	**Maximum**
January	7.05	7.85	28.53	4.7	9.4	28.9
February	12.83	8.67	30.10	0.0	8.6	31.5
March	97.17	10.22	30.08	26.4	11.4	33.6
April	114.82	11.57	28.97	239.5	12.2	28.5
May	148.35	11.60	27.9	170.6	11.3	28.0
June	67.79	9.69	27.71	94.8	10.6	27.2
July	85.63	12.23	26.47	96.3	11.0	26.9
August	129.33	18.481	26.93	56.8	10.7	27.3
September	144.84	20.69	27.31	100	10.8	28.8
October	72.87	10.41	28.29	36.3	10.0	28.9
November	23.66	3.38	28.30	48.7	8.2	29.2
December	2.03	0.29	27.91	9.7	7.9	29.1
Total	**852.04**	---	----	**883.8**	---	---
Average	--	10.14	26.48	-	10.17	28.99

Source: Regional Meteorological Station of Fadis Agricultural Research Center, Fadis, Eastern Hararghe Zone, Oromia, Ethiopia

Experimental Materials and Design

Twenty two sorghum genotypes developed from crosses of improved sorghum genotypes with known sources of *Striga* resistant genes and three standard checks, 'Gobiye' and 'SNR-39' as resistant and 'Teshale' as susceptible were used for field evaluation. The genotypes were advanced from the pedigree breeding program of the National Sorghum Improvement Program at Melkassa Agricultural Research Center and selfed up to F_6 stage, which were screened for resistance to *Striga* in *Striga* infested areas of Ethiopia.

The field experiment was conducted at the Fadis Research site on hot spot area for *Striga hermonthica* during the 2016 main cropping season. The treatments were arranged in 5 x 5 triple lattice designs. The plots size was two rows and 4.5 m long, with spacing of 75 cm between rows and 15 cm within rows. The distances

between replications and between plots were 1.5 m and 1 m, respectively. The seeds were manually drilled by hand into the rows, and the seedlings were thinned to 0.15 m distance between plants approximately 20 days after emergence.

Fertilizers were applied at rates of 100 kgha^{-1} and 40 kgha^{-1} DAP and Urea, respectively. The plots were weeded as frequently as needed by leaving the *Striga* weeds.

Data collection

Phonological and morphological data of sorghum such as; days to 50% emergence, days to 50% flowering, days to physiological, plant height (cm)**.**

Yield and yield components: - panicle length (cm), stand count, above ground biomass (AGB) (kg), 1000 kernels weight (g) grain yield (GY) (kg) adjusted to 12% moisture level, harvest index (HI).

Striga and Striga-related data: - Striga count at heading, flowering and harvest were taken from the sorghum plots. The Striga count data were square root transformed ($\sqrt{X + 0.5}$), where x is the original value.

Data analysis

Data were analyzed using Genstat 18th edition and treatment means were separated using the least significance difference (LSD) test at 5% level.

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) showed significant differences among the genotypes ($P \leq 0.05$) for all the traits measured. The tested genotypes showed highly significant ($P \leq 0.01$) variation on days to 50% flowering, *Striga* count at flowering and maturity, plant height, panicle length, days to maturity, grain yield, above ground biomass and thousand seed weight. Stand count at harvest for all genotypes was not significant, whereas harvest index showed significance difference ($P \leq 0.05$) (Table 2).

Table 2. Analysis of variance for *Striga*, growth and Phenological traits, and yield and yield related traits of 25 sorghum genotypes tested at Fadis in 2016/17

		Mean squares										
Source of variation	DF	FD	SCF	SCH	PH	PL	StC	DM	GY	AGB	TSW	HI
Replications	2	37.92	0.015	0.0225	21.37	2.93	2.8886	45.81	864839	9274032	7.84	89.13
Blocks within Replications (Adj.)	12	9.91	0.0069	0.1315	47.97	4.69	52362608	15.66	150452	1095616	5.1	24.73
Treatments (Unadj.)	24	62.49**	0.7379**	1.4428**	754.28**	16.19**	1.529^{ns}	106.05**	775216**	5623234**	22.4**	45.77*
Intra Block Error	36	11.46	0.0057	0.1055	46.92	2.4	1.3968	17.86	75655	1233966	5.4	28.9
RCBD Error	48	11.07	0.006	0.1120	47.18	2.97	1.1785	17.31	94354	1199378	5.33	27.86
Total	74	28.47	0.2436	0.5412	275.81	7.25	1.3384	46.86	335998	2852376	10.94	35.32

** and * -significant at $p \leq 0.01$ and $p \leq 0.05$ probability level, respectively, DF= Days to flowering; PH= Plant height; DM= Days to maturity; SCF= *Striga* count at flowering; SCH= *Striga* count at Harvesting; PL= Panicle length; StC= Stand count; GY= Grain yield; AGB= above ground biomass; TSW= Thousand seed weight; HI= Harvest Index

Days to 50% flowering

Flowering duration is one of the variety selection criteria, in particular in areas where drought and *Striga* are the major problems. The analysis of variance (Table 3) revealed that disparity in days to 50 percent flowering **(50%DF)** in sorghum genotypes was highly significant ($P \leq 0.01$). The overall average days to flowering was 74 days with a range of 68.3 days for the genotype ETSC 300003 to 85 days for the genotype 2006 MW 6112. Four of the late flowered sorghum genotypes 2006 MW 6112, 2006 MW 6044, 2006 MW 6123 and 2006 MW 6185 had similarity in flowering duration.

The early flowering genotypes ETSC 300003, 05 MW 6028, 05 MW 6073, ETSC 300081, ETSC 300085, 2006 MW 6067, ETSC 300086, ETSC 300087, 05 MW 6066, ETSC 300083, ETSC 300080, 05 MW 6005 and the two resistant checks (SRN-39 and Gobiye) were not significantly different in flowering time. These early genotypes could be potential genotypes for the target environment (Fadis), provided that they are resistant to *Striga* and give better yield. The genotypes have different genetic background, which might be the reason for the variation in flowering duration among the tested genotypes. These results are in line with the findings of Hassan (2005) and Ayelene (2011).

Plant height

The overall mean plant height (PH) recorded was 157.69 cm. Greater variation in plant height ranging from 113.3 to 194 cm was observed (Table 3). The maximum height was measured in genotype 2006 MW 6185 which

was the tallest (194.0 cm) among the 25 genotypes and produced more than 36.31 cm long and remained significantly taller than all the sorghum genotypes tested. From the sorghum genotypes evaluated 148 x Framida recorded shorter height of 128.0 cm. It was followed by genotypes 05 MW 6066, ETSC 300081, ETSC 300080, 2006 MW 6145, 2006 MW 6067, 05 MW 6028, 2006 MW 6112, ETSC 300083, and ETSC 300082, which were not significantly different from each other. These genotypes are important for areas were biomass is needed by farmers. The check variety Gobiye had the shortest mean (113.3 cm) PH. This finding is in line with the observation of Hesse and Lenné (1999) who stated that variability in plant height among sorghum progenies was attributed to genetic differences.

Days to physiological maturity

In present study, highly significant (P≤0.01) variation in days taken to physiological maturity (DM) was observed among various sorghum genotypes (Table 3). The physiological maturity period ranged from 116 to 138 days with a mean of 127.05 days. The genotype ETSC 300082 was the earliest (118.0 days) in physiological maturity and was not significantly different from the standard check (Gobiye), other three genotypes, namely; ETSC 300083, ETSC 300081, ETSC 300087, and one of the resistant check SRN-39 were early in maturity availing 116.3, 121.0, 122.0, 122.3 and 119.7 days, respectively (Table 3). All these lines were statistically comparable to each other, i.e. no significant differences. The latest maturing sorghum genotype was 2006 MW 6044, with a mean value of 138.0 days and statistically at par with genotypes 2006 MW 6112, 2006 MW 6145, 2006 MW 6067, 2006 MW 6185, 2006 MW 6123, 06 MW 6015 and the susceptible check (Teshale). Such types of variability in maturity have also been reported by earlier scientists. The normal maturing crops are usually considered ideal for grain yield. Delayed leaf senescence, or stay green in grain sorghum allows continued photosynthesis under drought conditions leading to normal grain filling and larger yields compared to senescent cultivars (Sami *et al.,* 2013).

Table 3: Mean values of phenological and growth parameters of sorghum genotypes tested at Fadis in 2016 cropping season

Genotype	Traits			
	DE	FD	PH(cm)	DM
1. 2006 MW 6044	9^{a}	82.3^{ab}	162.0^{c-g}	138.0^{a}
2. ETSC 300003	7^{d}	67.7^{h}	155.7^{f-h}	123.3^{e-i}
3. 05MW6019	8^{bc}	76.3^{c-f}	152.0^{gh}	126.7^{d-g}
4. 05 MW 6073	7.3^{cd}	69^{gh}	153.3^{gh}	125.7^{d-h}
5. 2006 MW 6185	9^{a}	80^{a-c}	194.0^{a}	132.3^{a-d}
6. ETSC 300081	7.3^{cd}	69.3^{gh}	171.3^{bc}	122.0^{f-j}
7. ETSC 300086	7^{d}	71.3^{f-h}	$157.^{7e-h}$	125.7^{d-h}
8. ETSC 300080	8^{bc}	73^{e-h}	169.3^{b-d}	123.3^{e-i}
9. 2006 MW 6145	9^{a}	75.3^{c-f}	169.0^{b-d}	135.7^{a-c}
10.ETSC 300087	7.3^{cd}	71.7^{f-h}	156.7^{f-h}	122.3^{f-j}
11.2006 MW 6112	8.6^{ab}	85^{a}	163.0^{b-g}	136.7^{ab}
12.148 X Framida	8.6^{ab}	74.3^{d-g}	128.0^{i}	123.3^{e-i}
13.05 MW 6066	7.6^{cd}	71.7^{f-h}	173.7^{b}	129.3^{c-e}
14.06 MW 6015	8^{bc}	77.7^{b-e}	150.3^{h}	131.3^{a-d}
15.ETSC 300085	7.3^{cd}	69.7^{gh}	152.0^{gh}	126.3^{d-h}
16.2006 MW 6067	7.6^{cd}	71^{f-h}	168.7^{b-e}	135.3^{a-c}
17.05 MW 6005	8^{bc}	73^{e-h}	153.7^{gh}	128.0^{d-f}
18.ETSC 300083	7.6^{cd}	72.3^{e-h}	165.7^{b-f}	121.0^{g-j}
19.ETSC 300082	7.6^{cd}	77.7^{b-e}	$162.^{7b-g}$	118.0^{ij}
20.05 MW 6028	7.6^{cd}	68.3^{h}	163.0^{b-g}	123.3^{e-i}
21.2006 MW 6123	8^{bc}	80.3^{a-c}	153.7^{gh}	131.3^{a-d}
22.SPV-245 X 1(146 X 354)-27 xFramida-7-1	8^{bc}	75.7^{c-f}	$162.^{3c-g}$	130.0^{b-e}
23.SRN-39	8.7^{ab}	73^{e-h}	131.7^{i}	119.7^{h-j}
24.Teshale	9^{a}	79^{b-d}	$159.^{7d-h}$	131.3^{a-d}
25.Gobiye	7.3^{cd}	72.3^{e-h}	113.3^{j}	116.3^{j}
LSD (5%)	0.94	5.46	11.28	6.83
CV (%)	7.2	4.5	4.4	3.3

Means with the same letters are not significantly different from each other'; DE= days to 50% emergence; DF= days to 50% flowering; PH= plant height; DM= days to maturity

Yield and yield components

Panicle length

Analysis of variance for panicle length (PL) showed highly significant ($P \leq 0.01$) difference among genotypes (Table 4). The overall average value for PL was 23.4 cm, with the range between 19.67 and 29.00 cm (Table 4). The genotype 2006 MW 6044 had the longest (29.0 cm) PL followed by the genotype 2006 MW 6145 and 148 x Framida. The shortest (19.7 cm) panicle was recorded in susceptible check Teshale, which was not significantly different from genotypes;05 MW 6073, ETSC 300086, ETSC 300080, 05 MW 6005, ETSC 300083, ETSC 300082, Spv-245x1(146 x 354)-27 x Framida-7-1 and one of the resistant check SRN-39. From this study, PL and the grain yield were not directly relationship in which some genotypes recorded longest PL, but did not produced highest grain yield and vice versa.

Aboveground dry biomass (AGB)

Analysis of variance (ANOVA) showed highly significant ($P \leq 0.01$) differences in aboveground dry biomass yield among the genotypes with a mean of 5949.4 $kgha^{-1}$ and arrange of 3243to 10457 $kgha^{-1}$(Table 6). Genotype 2006 MW 6185 had the highest (10457 kg ha^{-1}) AGB yield, whereas the smallest (3243 kg ha^{-1}) was recorded for ETSC 300087) (Table 4). The genotypes 2006 MW 6185 had highest grain yield and AGB. However, the line ETSC 300087 had the lowest values of both grain yield and above ground dry biomass. This genotype supported high *Striga* plants and was judged as susceptible to *Striga*. This result confirms the findings of Ast *et al.* (2000) who reported that the AGB in Tiemarifing (tolerant sorghum landrace) was found to be three times greater than that of CK60-B (sensitive sorghum cultivar).

Thousand Seed weight

Grain size is an important yield component as it is directly proportional to seed yield. Thousand seed weight (TSW) was highly significantly ($P \leq 0.01$) different among the genotypes (Table 4). The overall average 1000 seed weight was 24.70 g with a range of 29.7 to 39.33 g. The heaviest seeds (39.3 g per 1000 seed) were produced by genotype ETSC 300080 followed by 2006 MW 606, ETSC 300085, 05 MW 6073, ETSC 300086 and 05 MW 6005 which in turn showed 38.7, 38.3, 37.7, 37.7 and 36.7 g, respectively and were not significant from the heaviest genotype. The smallest size grain was found in genotype SRN-39 (29.7 g) and at par with eight sorghum genotypes tested. In this study variability on TSW were observed among sorghum genotypes, which differed in their seed size and the yield recorded from them. Similar observations regarding variability in weight of grains in sorghum were also reported by Muhammad *et al.* (2015).

Grain yield

The variability in grain yield (GY) produced by different sorghum genotypes was found to be highly significant ($P \leq 0.01$). The mean GY value of the genotypes ranged from 1068 to 3283 kg ha^{-1}, indicating large variation among the genotypes (Table 4). This large yield variation with other important parameters among genotypes could help in the selection of superior genotypes for the area. The highest (3283 kg ha^{-1}) grain yield was obtained from 2006 MW 6185. In addition, four genotypes (SPV-245 X 1(146 X 354)-27 X Framida-7-1, 05 MW 6073, ETSC 300003 and 05 MW 6005) gave high yields (Table 4). These lines were statistically at par with each other and significantly better than rest of 20 sorghum genotypes.

In comparison to the *Striga* resistant check variety (SRN 39), two genotypes namely 2006 MW 6185 and SPV-245 X 1(146 X 354)-27 XFramida-7-1 gave higher mean GY. Twelve of the tested genotypes out yielded the standard check variety (Gobiye), indicating the possibility of obtaining better yielding varieties. However, the lowest 1068 kg ha^{-1} grain yield was obtained from genotype 05 MW 6028, followed by 2006 MW 6067 (1093 kg ha^{-1}), 05 MW 6019 (1287 kg ha^{-1}), ETSC 300087 (1293 kg ha^{-1}), 06 MW 6015 (1310 kg ha^{-1}), 05 MW 6066 (1445 kg ha^{-1}) and 2006 MW 6044 (1560 kg ha^{-1}). These genotypes were not significantly different from each other and showed poor performance. The highest range of genetic variability in grain yield of sorghum genotypes were observed similar to this study was also reported by Muhammad *et al.* (2015).

Table 4: Mean values of yield, yield related for the genotypes tested at Fadis in 2016 crop season

Genotype	Traits					
	PL (cm)	StC	GY (kg ha^{-1})	AGB (kg ha^{-1})	1000SW (g)	HI
1. 2006 MW 6044	29.0^{a}	46420	1560^{f-j}	5195^{e-i}	32.3^{d-g}	29.8^{c-h}
2. ETSC 300003	23.4^{c-g}	59753	2329^{b-d}	7668^{bc}	34.3^{c-f}	30.3^{c-g}
3. 05MW6019	23.3^{c-g}	38025	1287^{h-j}	4244^{ij}	35.3^{b-d}	30.3^{c-g}
4. 05 MW 6073	22.2^{e-h}	44938	2397^{bc}	6538^{b-e}	37.7^{a-c}	36.5^{ab}
5. 2006 MW 6185	23.0^{d-g}	58765	3283^{a}	10457^{a}	35.0^{b-e}	31.3^{b-f}
6. ETSC 300081	22.9^{d-g}	51358	1968^{c-f}	5708^{d-i}	32.3^{d-g}	34.8^{a-c}
7. ETSC 300086	22.4^{e-h}	57778	1815^{e-g}	5830^{d-i}	37.7^{a-c}	31.0^{b-g}
8. ETSC 300080	21.4^{f-h}	54815	1818^{e-g}	6267^{b-f}	39.3^{a}	29.1^{c-h}
9. 2006 MW 6145	28.9^{ab}	39506	1771^{f-h}	6039^{c-h}	32.3^{d-g}	30.2^{c-g}
10. ETSC 300087	23.4^{c-g}	52346	1293^{h-j}	3243^{j}	35.3^{b-d}	40.5^{a}
11. 2006 MW 6112	24.3^{c-e}	47407	1992^{c-f}	7034^{b-d}	32.7^{d-g}	28.0^{d-h}
12. 148 X FRAMIDA	26.1^{bc}	49877	1607^{f-i}	5150^{e-i}	30.0^{g}	30.8^{b-g}
13. 05 MW 6066	24.3^{c-e}	57284	1445^{g-j}	6071^{b-h}	35.3^{b-d}	23.9^{hi}
14. 06 MW 6015	22.8^{e-g}	47407	1310^{h-j}	6394^{b-f}	31.3^{e-g}	20.7^{i}
15. ETSC 300085	24.1^{c-f}	48889	1841^{d-g}	5853^{d-i}	38.3^{ab}	32.0^{b-f}
16. 2006 MW 6067	23.9^{c-f}	46914	1093^{j}	4447^{h-j}	38.7^{ab}	25.1^{g-i}
17. 05 MW 6005	20.9^{gh}	60741	2315^{b-e}	6909^{b-d}	36.7^{a-c}	33.7^{b-e}
18. ETSC 300083	20.8^{gh}	59259	1638^{f-i}	5473^{d-i}	32.3^{d-g}	30.5^{b-g}
19. ETSC 300082	21.4^{f-h}	50370	1677^{f-i}	6151^{b-g}	35.0^{b-e}	28.4^{d-h}
20. 05 MW 6028	23.1^{d-g}	55803	1068^{j}	4420^{h-j}	35.0^{b-e}	24.9^{g-i}
21. 2006 MW 6123	24.8^{c-e}	36543	1826^{d-g}	6736^{b-e}	34.3^{c-f}	27.7^{e-h}
22.Spv-245x1(146 x 354)-27 x Framida-7-1	20.8^{gh}	58765	2535^{b}	7746^{b}	35.3^{b-d}	32.8^{b-e}
23. SRN-39	20.8^{gh}	59753	2017^{c-f}	5907d-i	29.7^{g}	34.1^{b-d}
24. Teshale	19.7^{h}	49383	1660^{f-i}	4740^{f-j}	31.0^{fg}	35.2^{a-c}
25. Gobiye	25.7^{cd}	44444	1190^{ij}	4516^{g-j}	31.6^{d-g}	26.5^{f-i}
LSD (5%)	2.83	NS	504.28	1687.41	3.79	6.20
CV (%)	7.4	21.3	17.2	17.3	6.7	12.5

N.B. 'Means with the same letters are not significantly different from each other'; PL= Panicle length; StC = Stand count; GY= Grain yield; AGB= Above ground biomass; 1000SW= 1000 seed weight; HI= Harvest index

Harvest Index

Analysis of variance showed significant ($P \leq 0.05$) difference was observed among the genotypes tested. The Harvest Index (HI) values ranged from 20.7 to 40.5% in (Table 4). The highest value (40.5%) was shown by genotype ETSC 300087 followed by genotypes 05 MW 6073, Teshale, and ETSC 300081 which were at par with the genotype of the highest HI. The lowest (20.7%) harvest index was recorded from the genotype 06 MW 6015. The genotypes 05 MW 6066, 05 MW 6028, 2006 MW 6067 and one of the resistant checks Gobiye were also recorded lower HI, which were at par with the least value recorded by the genotype 06 MW 6015. From this study the lowest HI values were observed from the genotypes of lower yield and the highest HI were also recorded from more of the genotypes achieved good yield. This implies the partitioning of the yield components to yield was better and were important for selection criteria of the genotypes.

***Striga* count**

The mean number of *Striga* count was 24.7 per hectare which was the lowest number of *Striga* emergence in the area. This could be related to the seasonal variability for the *Striga* for preconditioning and germination (Logan and Stewart 1991). However, there was variability of *Striga* infestation among the genotypes tested in the area.

Analysis of variance showed that the number of *Striga hermonthica* at 50% flowering and maturity of sorghum genotypes were highly significant ($P \leq 0.01$) (Table 5). The mean number of emerged *Striga* plant per plot at 50% sorghum flowering ranged from zero (0) in ETSC 300003, ETSC 300080, 2006 MW 6145, ETSC 300082, 05 MW 6028, 2006 MW 6123, SRN-39, Gobiye to 2.07 in susceptible check (Teshale). Generally, 10 sorghum genotypes [were recorded lower *Striga* germination] and were not significantly different from the two resistant checks. The highest number of *Striga* was recorded on sorghum genotypes 2006 MW 6112 and 2006 MW 6067 (1.82plants per plot each), which was not significantly different from the susceptible check (Teshale) (2.07 plants per plot) (Table 5). Similarly, genotypes SPV-245 x 1(146 X 354)-27 x Framida-7-1 and ETSC

300083 recorded the same values of 1.52 plants per plot, which was at par with the susceptible check (Teshale).

In present study the *Striga* count at maturity in various sorghum genotypes were also remained significant (Table 5). The mean *Striga* count per sorghum genotypes at maturity of the sorghum were varied between zero (0) to 1.28 per plot. Out of the 25 tested genotypes, 18 supported few number of *Striga* plants per plot and had similar reaction with the two resistant check varieties (Table 5). The variety 2006 MW 6067 had the highest *Striga* count (1.28 plot^{-1}) followed by genotypes 06 MW 6015 and ETSC 300083 with the value of 1.14 each. These genotypes were supporting more *Striga* plants than the susceptible check, and were significantly different from the check. Generally, sorghum genotypes 2006 MW 6044, ETSC 300003, 05 MW 6019, ETSC 300081, ETSC 300080, 2006 MW 6145, 05 MW 6005, ETSC 300082, 05 MW 6028 and 2006 MW 6123 did support either no or fewer *Striga* plants both at 50% flowering and physiological maturity, which might suggest the level of resistance as it has been outlined in previous reports. Doggett (1988) and *Ejeta et al*. (1992) reported that crop genotypes which, when grown under conditions of *Striga* infestation, support significantly fewer *Striga* plants and have higher yields than the susceptible cultivars are considered as resistant to *Striga*.

Table 5: 1Mean values of *Striga* count at 50% flowering and maturity per plot tested at Fadis during 2016 crop season

	Traits	
Genotype	SCF/plot	SCH/plot
2006 MW 6044	0.33(0.3)fg	0(0)d
ETSC 300003	0(0)g	0(0)d
05MW6019	0.33(0.3)fg	0(0)d
05 MW 6073	0.8(1)d-f	1(1)c
2006 MW 6185	1.28(1.7)b-d	0(0)d
ETSC 300081	0.33(0.3)fg	0(0)d
ETSC 300086	0.67(0.7)ef	0(0)d
ETSC 300080	0(0)g	0(0)d
2006 MW 6145	0(0)g	0(0)d
ETSC 300087	1.28(1.7)b-d	1(1)c
2006 MW 6112	1.82(3.3)ab	1(1)c
148 X Framida	1.28(1.7)b-d	0(0)d
05 MW 6066	1.14(1.3)c-e	0(0)d
06 MW 6015	1.28(1.7)b-d	1.14(1.33)b
ETSC 300085	1.14(1.3)c-e	0(0)d
2006 MW 6067	1.82(3.3)ab	1.28(1.67)a
05 MW 6005	0.33(0.3)fg	0(0)d
ETSC 300083	1.52(2.3)a-c	1.14(1.33)b
ETSC 300082	0(0)g	0(0)d
05 MW 6028	0(0)g	0(0)d
2006 MW 6123	0(0)g	0(0)d
SPV-245 X 1(146 X 354)-27 XFramida-7-1	1.52(2.3)a-c	0(0)d
SRN-39	0(0)g	0(0)d
Teshale	2.07(4.3)a	1(1)c
Gobiye	0(0)g	0(0)d
Mean	0.8	0.3
LSD(0.05)	0.55	0.13
CV%	44.4	26.7

Figures in the parenthesis are the original values; Numbers outside the parentheses are square root-transformed $\sqrt{x + 0.5}$'; Means with the same letters are not significantly different from each other'; SCF= *Striga* Count at 50% flowering; SCH= *Striga* count at physiological maturity.

CONCLUSION

Generally, even though the season was not conducive for maximum *Striga* emergence in the field, the significant variation were observed among the genotypes studied and it is suggested that the continuation of the experiments using the promising lines would confirm their resistance. Future research efforts should be directed towards understanding host resistance mechanisms and improvement of field screening at multiple hot spot areas. As the response mechanisms of *Striga* resistance in sorghum genotypes are distinct, post-attachment and marker assisted selection should be employed to observe the real resistant genotypes.

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