Weed Technology

www.cambridge.org/wet

Research Article

Cite this article: Earecho MK and Nebiyu E (2025) Evaluation of Western Ethiopian Sorghum Landraces for Resistance to *Striga hermonthica* (Delile) Benth. Weed Technol. **39**(e51), 1–7. doi: 10.1017/wet.2025.21

Received: 13 April 2024
Revised: 20 January 2025
Accepted: 7 March 2025

Associate Editor:
Charles Geddes, Agriculture and Agri-Food Canada

Nomenclature:
Purple witchweed; *Striga hermonthica* (Delile) Benth.; corn; *Zea mays* L.; Millets; *Eleusine coracana* Gaertn. and *Cenchrus americanus* (L.) Morrone; rice; *Oryza sativa* L.; sorghum; *Sorghum bicolor* (L.) Moench

Keywords:
Striga; resistance; parasitic weed

Corresssponding author:
Minyahil Kebede Earecho;
Email: minishkebe@gmail.com

Evaluation of Western Ethiopian Sorghum Landraces for Resistance to *Striga hermonthica* (Delile) Benth

Minyahil Kebede Earecho[1] and Esubalew Nebiyu[1]

[1]Researcher, Department Plant Protection Research, Ethiopian Institute of Agricultural Research, Assosa Agricultural Research Center, Assosa, Benishangul Gumuz, Ethiopia

Abstract

Purple witchweed is a hemiparasitic plant that significantly affects sorghum yields in semiarid regions. It also affects crops such as corn, millets, and rice. Developing purple witchweed-resistant sorghum varieties is an essential element in integrated purple witchweed management. This study evaluated the response of 48 sorghum genotypes to purple witchweed grown both in pots and in field conditions. Resistant varieties (Berhan and Framida) and susceptible varieties (Assosa-1, Adukara, and ETSL102967) were used as controls. The findings revealed substantial variability among the sorghum landraces in their response to purple witchweed. Purple witchweed density was less when seeds were grown with early maturing sorghum genotypes, while late-maturing genotypes were more susceptible to the weed. Notably, the ETSL102969 landrace showed strong resistance, comparable to that of Berhan. Additionally, the ETSL102970 landrace demonstrated superior resistance to purple witchweed compared to Framida. Based on these results, ETSL102969 and ETSL102970 are recommended as valuable sources of resistance for breeding programs aiming to improve sorghum resistance against purple witchweed in Ethiopia.

Introduction

Purple witchweed is a hemiparasitic flowering weed belonging to the *Orbanchaceae* family (Matusova et al. 2005; Mohamed and Musselman 2008). It is globally widespread and damaging (Ejeta and Gressel 2007; Oswald 2005; Parker 2009), and is particularly prevalent in sub-Saharan Africa (Gethi and Smith 2004; Mohamed and Musselman 2008; Rodenburg et al. 2016). Purple witchweed severely affects production of sorghum [*Sorghum bicolor* (L.) Moench], corn (*Zea mays* L.), millets [*Eleusine coracana* Gaertn. and *Cenchrus americanus* (L.) Morrone], tef [*Eragrostis tef* (Zucc.) Trotter], rice (*Oryza sativa* L.), and even sugarcane (*Saccharum officinarum* L.) (Addisu and Feleke 2021; Atera and Itoh 2011; Atera et al. 2012; Kountche et al. 2016; Parker 2012; Spallek et al. 2013). The weed drastically reduces agricultural productivity for small-scale subsistence farmers in sub-Saharan Africa, including Ethiopia, and is considered the most devastating biological barrier to cereal production (Omanya et al. 2004).

Several studies have highlighted the widespread infestation of purple witchweed in Ethiopia. Gebreslasie et al. (2016) reported moderate to severe infestation throughout Tigray. Degebasa et al. (2022) found it to be the dominant species in eastern and western Hararghe, Oromia. In Benishangul Gumuz, purple witchweed poses a significant challenge to sorghum production across almost all districts. The impact on sorghum production in Ethiopia is significant and widespread. Yield losses due to purple witchweed infestation range from 65% to 100% (Bayable and Marcantonio 2013; Ejeta et al., 1993; Haussmann et al. 2000; Degebasa et al. 2022; Tesso et al. 2007). In Benishangul Gumuz, purple witchweed is the primary factor affecting sorghum production (Mesfin and Girma 2022). The detrimental effects extend beyond Ethiopia to other countries in eastern and West Africa (Ejeta and Gressel 2007). These points underscore the necessity of developing effective strategies to manage and control purple witchweed to mitigate its devastating impact on sorghum production in the Benishangul Gumuz region and other affected areas in Ethiopia. The use of resistant crop varieties has been proposed as a practical and cost-effective long-term strategy for managing purple witchweed (Hearne 2009; Mandumbu et al. 2019). Therefore, this study aimed to identify sorghum genotypes that are resistant to purple witchweed.

Materials and Methods

Plant Materials

The sorghum genotypes in this study were selected from landraces collected from farmers' fields in Ethiopia, specifically in Benishangul Gumuz and some parts of western Oromia regions.

Table 1. Sources of 49 sorghum genotypes used in the study.[a]

S/N	Genotype	Standardized name	Source	S/N	Genotype	Standardized name	Source
1	Mok 079/1	ETSL102954	Mao-Komo, BGR	26	AScol19-Kok001	ETSL102976	Keshmando, BGR
2	ETSCAs 10020-2-116-2	ETSC20001	AsARC	27	AScol19-SG 002	ETSL102952	Selga, BGR
3	AScol19-Al25	ETSL102971	Assosa, BGR	28	ETSCAs 10015-2-102-1	ETSC19003	AsARC/Ethiopia
4	AScol19-KA021/1	ETSL102972	Kamashi, BGR	29	Y039-1	ETSL102956	Yaso, BGR
5	ETSCAs 10015-2-103-1	ETSC19001	AsARC	30	AScol19-As-7	ETSL102946	Assosa, BGR
6	AScol19-As-2	ETSL102943	Assosa, BGR	31	AScol19-SG 001	ETSL102951	Selga, BGR
7	ETSCAs 10019-1-110-1	ETSC19002	AsARC	32	ETSCAs 10007-2-61-1	ETSC19004	AsARC
8	Ya 036/1	ETSL102957	Yaso, BGR	33	AScol19-As -14	ETSL102940	Assosa, BGR
9	ETSCAs 10001-1-4-1	ETSC20002	AsARC	34	AScol19-Krm122	ETSL102969	Kurmuk, BGR
10	AScol19-As-6	ETSL102945	Assosa, BGR	35	ETSCAs 10019-1-115-1	ETSC19005	AsARC
11	AScol19-As-13	ETSL102942	Assosa, BGR	36	Bam075	ETSL102918	Bambasi, BGR
12	AScol19-As-1	ETSL102941	Assosa, BGR	37	Bmb097	ETSL102905	Bambasi, BGR
13	AScol19-JW128	ETSL102973	Jawi, AmR	38	Bmb095	ETSL102920	Bambasi, BGR
14	AScol19-As-8	ETSL102947	Assosa, BGR	39	NJ003	ETSL102912	Nejo, OrR
15	AScol19-Krm 124	ETSL102974	Kurmuk, BGR	40	Mok087	ETSL102925	Mao Komo, BGR
16	AScol19-As-5	ETSL102944	Assosa, BGR	41	Man069	ETSL102922	Mao Komo, BGR
17	ETSCAs 10002-2-13-1	ETSC20003	AsARC	42	Boj007	ETSL102904	Bambasi, BGR
18	Mok 079/2	ETSL102955	MaoKomo, BGR	43	Mok085	ETSL102919	Mao Komo, BGR
19	ETSCAs 10020-2-116-1	ETSC20004	AsARC	44	ETSC 300382-1	ETSC20006	AsARC
20	ETSCAs 10003-3-32-1	ETSC20005	AsARC	45	Qon072	ETSL102896	Qondala, OrR
21	Adukara (Susceptible)	Adukara	Released in 2015	46	Y047	ETSL100053	Yaso, BGR
22	AScol19-Krm123	ETSL102970	Kurmuk, BGR	47	Assosa-1 (2015)	Assosa-1	Released in 2015
23	AScol19-AB126	ETSL102975	Abramo, BGR	48	Berhan (2002)	Berhan	MARC
24	AScol19-JW127	ETSL102949	Jawi, AmR	49	Framida	Framida	MARC
25	AScol19-BS 082/1	ETSL102948	Bambasi, BG				

[a]Abbreviations: AmR, Amhara Region/Ethiopia; AsARC, Assosa Agricultural Research Center; BGR, Benishangul Gumuz Region/Ethiopia; ETSL, Ethiopian sorghum landrace; MARC, Melkassa Agricultural Research Center/Ethiopia; OrR, Oromia Region/Ethiopia; S/N, serial number.

The study included 49 genotypes and four released varieties (Table 1). Resistant checks, Berhan and Framida, were obtained from the Melkassa Agricultural Research Center. The use of check varieties allowed for effective assessment of resistance to purple witchweed. Purple witchweed seeds used in this study were collected over 3 yr (2019 to 2021) from heavily infested sorghum fields in various districts of Assosa Zone, including Bambasi, Abramo, and Ura. The seeds were stored in glass jars and kept in the dark at room temperature until needed for the trials.

For the pot trials, 48 sorghum genotypes were used, including both susceptible and resistant checks. Assosa-1 and Adukara served as the susceptible checks, while Berhan was the resistant check. From these initial tests, 33 genotypes were selected for further evaluation in a specially designed purple witchweed sick plot at the Assosa Agricultural Research Center. This phase included another resistant check, Framida. To validate the pot and sick plot trials, seven sorghum genotypes, including resistant checks Berhan and Framida and promising resistant landraces ETSL102969, ETSL102970, and ETSL102975, alongside susceptible checks Assosa-1 and ETSL102957, were evaluated in farmers' fields at three locations in Assosa, Benishangul Gumuz Region.

Study Sites, Trial Design, and Procedures

The trials were established at the Assosa Agricultural Research Center located between 10.0432°N and 34.5687°E, 1,553 m asl, in the Assosa Zone of the Benishangul Gumuz Region. The area receives a mean annual rainfall of 1,177 mm and has a mean temperature of 26.8 C.

The pot trials were laid out in a randomized complete block design with two replications in 2020 and 2021 under Lath-house conditions (temperature, 21–28 C; 12-h light/dark photoperiod; watered twice per week). A mix of sand, peat, and compost (1:3:1 volume/volume) filled 96 round plastic pots with a diameter of 27 cm at the top, 22 cm at the bottom, and height of 28.5 cm. Each pot received 4 mg of purple witchweed seeds, which were covered with a thin layer of soil mix (up to 5 cm depth). After a 10-d preconditioning period for the purple witchweed seeds, six sorghum seeds of each genotype were sown and later thinned to three plants per pot. The pots were not fertilized to enhance purple witchweed emergence.

In 2022, 33 sorghum genotypes were evaluated in purple witchweed sick plots at the center. The site was plowed twice with a tractor, and furrows spaced 70 cm apart were prepared with a furrow maker. The trial was laid out in a randomized complete block design with two replications. Furrows within each plot (2 m × 1.40 m) were uniformly infested with purple witchweed seeds collected during the 2021 cropping season. These seeds were covered with a thin soil layer and preconditioned for 10 d. Sorghum genotypes were then sown in the furrows at a rate of 10 kg ha^{-1}. Aside from purple witchweed, other weeds were hand-weeded as observed, and recommended fertilization such as 100 kg ha^{-1} NPS (19 kg nitrogen, 38 kg P_2O_5, and 7 kg sulfur) at sowing and 50 kg ha^{-1} urea after thinning was followed.

For validation, a trial was designed in a randomized complete block design with three replications, using farmers' fields as replications. Seven selected sorghum genotype were tested using plot sizes of 4.20 m × 4.05 m for each genotype. Weeds, except purple witchweed, were manually removed, and recommended fertilization was followed.

Data Collection and Analysis

Data were collected on both sorghum and purple witchweed parameters. For sorghum, the data included days to 50% anthesis, days to maturity, plant height, number of leaves, biomass, and dry matter (grams per pot). For purple witchweed, recorded data

https://doi.org/10.1017/wet.2025.21

included emerged purple witchweed height and count at weekly intervals from the 7th to 12th week after crop emergence (WACE). Additionally, we measured purple witchweed biomass and dry matter.

To determine the maximum aboveground purple witchweed, we followed the methods suggested by Rodenburg et al. (2006). The area under purple witchweed number progress curve (ASNPC) was calculated as suggested by (Haussmann et al., 2012) as follows:

$$ASNPC = \sum_{i=0}^{n-1} \left(\frac{Y_i + Y_{(i+1)}}{2}\right)\left(t_{(i+1)} - t_i\right) \quad [1]$$

where n is the number of purple witchweed recording dates, Y_i is the purple witchweed count at the i^{th} assessment date, and t_i is the number of days after sowing at the i^{th} assessment date.

ANOVA was carried out using the LMER() package in R software (R Core Team 2023), where sorghum genotypes were the fixed effect, while years, replication, and errors were random effects. Residual analysis was performed using the SHAPIRO.TEST package to ensure the normal distribution of residuals. The randomized complete block design model used was as follows:

$$Y_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij} \quad [2]$$

where, Y_{ij} is the observed value for the experimental unit in the j^{th} replication (r) assigned to the i^{th} genotype, $j = 1, 2 \ldots r$ and $i = 1, 2,..$, μ is the overall mean, α is the effect due to the i^{th} treatment, β is the effect due to the j^{th} block, and ε_{ij} is the error term, where error terms are independent observations from an approximately normal distribution with mean equal to zero and constant variance σ^2_{ε}.

An independent sample *t*-test assessed the significant differences in the performance of various sorghum genotypes against purple witchweed. Treatment means were separated using Tukey's HSD procedure at a 5% probability level. Additionally, sorghum genotypes were hierarchically clustered based on the number of purple witchweed plants that emerged per sorghum plant using the Euclidean distance matrix. Ward's linkage method was utilized with MINITAB software version 14.

Table 2. Response of sorghum landraces to artificially infested purple witchweed grown in pots at Assosa, Benishangul Gumuz, Ethiopia.[a,b,c]

Genotypes	Purple witchweed per sorghum	Genotypes	Purple witchweed per sorghum
	No.		No.
Berhan	0.08 c	ETSC19004	3.92 a-c
ETSL102969	0.17 c	ETSL102925	3.92 a-c
ETSL102970	0.33 c	ETSL102944	4.00 a-c
ETSC20003	0.67 c	ETSC20006	4.08 a-c
ETSL102971	0.75 c	ETSL102948	4.25 a-c
ETSL102975	0.75 c	ETSC20001	4.34 a-c
ETSL102904	0.92 c	ETSL102922	4.42 a-c
ETSC19001	1.25 bc	Assosa-1	4.83 a-c
ETSC19003	1.42 bc	ETSL102942	4.92 a-c
ETSC20005	1.67 bc	ETSC19005	4.92 a-c
ETSL102949	1.67 bc	ETSL102972	5.42 a-c
ETSC20002	1.75 bc	ETSL102946	5.67 a-c
ETSL102920	2.50 a-c	ETSL102918	5.83 a-c
ETSL102974	2.67 a-c	ETSL102952	6.08 a-c
ETSL102941	3.17 a-c	ETSL102955	6.42 a-c
ETSL102951	3.17 a-c	ETSC20004	6.58 a-c
ETSC19002	3.42 a-c	ETSL102956	6.67 a-c
ETSL102912	3.42 a-c	ETSL100053	6.83 a-c
ETSL102976	3.50 a-c	Adukara	6.92 a-c
ETSL102919	3.50 a-c	ETSL102905	7.00 a-c
ETSL102896	3.67 a-c	ETSL102947	7.17 a-c
ETSL102954	3.84 a-c	ETSL102940	8.50 ab
ETSL102945	3.84 a-c	ETSL102957	9.42 a
ETSL102943	3.92 a-c	ETSL102973	9.92 a
Mean	4.04		4.04
Tukey's MSD	7.43		7.43
CV	63.97		63.97
P value	<0.0001		<0.0001

[a]Abbreviations: CV, coefficient of variation; MSD, minimum significant difference; WACE, weeks after crop emergence.
[b]Means within the same column followed by the same letter are not statistically different according to Tukey's MSD (α = 0.05).
[c]Purple witchweed plants were counted at 12 wk after crop emergence. Experiments were conducted in 2020–2021.

Results and Discussion

Response of Sorghum Landraces to Purple Witchweed

Pot Trial

The mean number of emerged purple witchweed plants per pot across all sorghum genotypes was 12.13, and the mean number of purple witchweed plant per sorghum plant was 4.04 (Table 2). This indicates there was an adequate level of infestation to determine the resistance of sorghum genotypes to purple witchweed.

The pot experiment results showed a highly significant difference ($P < 0.0001$) in the response of sorghum landraces to purple witchweed infestation (Table 2). The average number of emerged purple witchweed plants per pot ranged from 0.25 for the Berhan variety (resistant check) to 29.75 for the ETSL102973 landrace. Similarly, the number of purple witchweed plants per sorghum plant ranged from 0.08 for Berhan to 9.92 for ETSL102973. These findings suggest that more purple witchweed plants emerged from the pots that contained ETSL102973 sorghum seeds compared with pots that contained Berhan seeds, indicating its susceptibility to purple witchweed (Table 2 and Figure 1). On the other hand, fewer purple witchweed plants emerged in pots with sorghum landraces ETSL102969 and ETSL102970 compared to other landraces (Table 2; Figure 2).

Purple Witchweed Sick-Plot Trial

The purple witchweed sick-plot experiment revealed significant variation ($P < 0.05$) among sorghum landraces in the mean number of emerged purple witchweed plants per plot at 12 WACE. Purple witchweed emergence per plot varied depending on the sorghum genotype that was also planted, ranging from 3.0 for Berhan and ETSL102969 to 148.5 for ETSL102944. Similarly, the number of emerged purple witchweed plants per sorghum plant ranged from 0.22 for ETSL102966 to 5.48 for ETSL102954 (Table 3; Figure 1). The results indicated that purple witchweed emergence (3.0 per plot) was lowest in pots with the resistant check Berhan and sorghum landrace ETSL102969. Purple witchweed emergence was also lower in pots with sorghum landraces ETSL102970, ETSL102975, ETSL19001, and ETSL100053than in the sick-plot trial with the resistant check variety Framida. These results are consistent with the findings from previous pot trials (Tables 2 and 3).

The study showed that the resistant sorghum genotypesmature early, with maturity periods of 125 d for Berhan, 142 d for ETSL102970, and 144 d for ETSL102969 (Table 3). This finding aligns with reports by Ayana et al. (2019), that early maturing

https://doi.org/10.1017/wet.2025.21

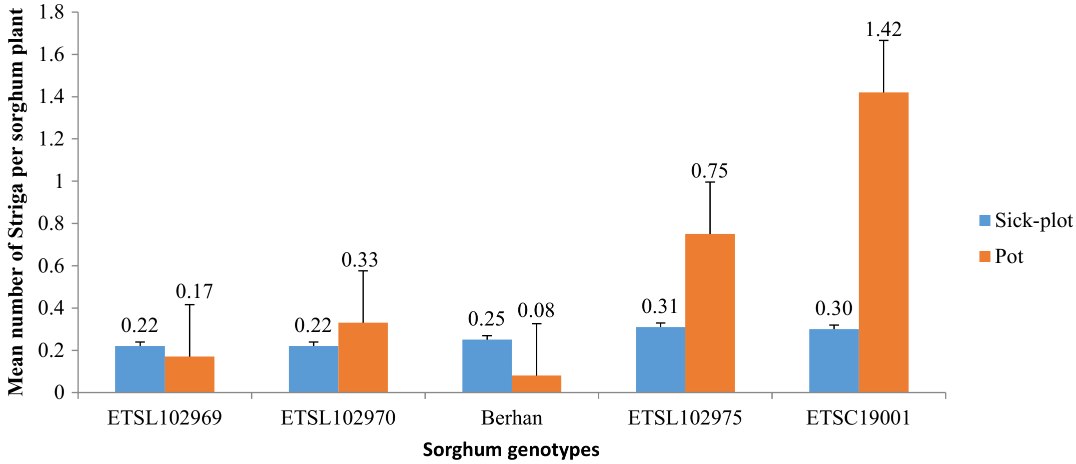

Figure 1. Top five sorghum genotypes with lowest emerged purple witchweed count per sorghum plant from 2020 to 2022 at Assosa, Benishangul Gumuz, Ethiopia. Error bars indicate standard error of uncertainty in the average number of purple witchweed plants per sorghum plant. Tukey's minimum significant difference = 1.02.

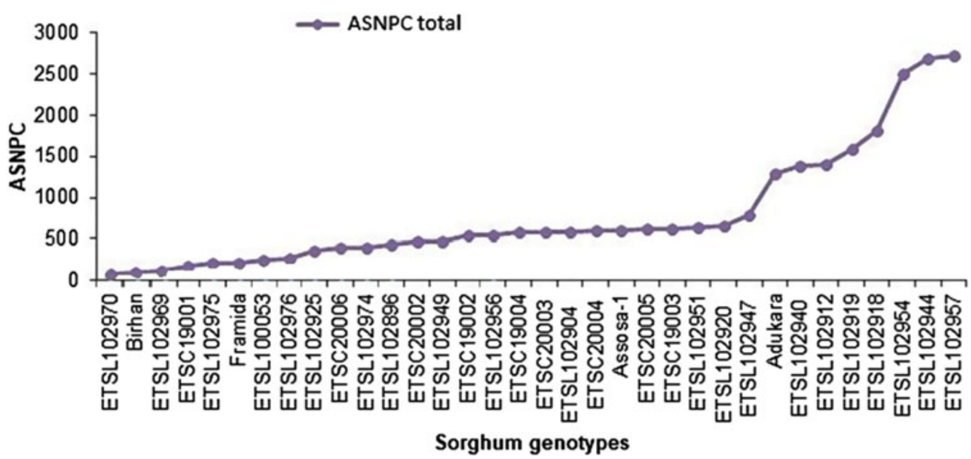

Figure 2. Reaction of sorghum genotypes to area under purple witchweed number progress curve (ASNPC) at Assosa, Benishangul Gumuz, Ethiopia

sorghum genotypes show resistance to purple witchweed. Franke et al. (2006) also found that earlier maturing sorghum genotypes responded positively to purple witchweed stress. Additionally, the purple witchweed-resistant sorghum genotypes in this study ranged in height from 102 cm for ETSL102969 to 140 cm for Berhan. They also had fewer leaves per plant, ranging from four for ETSL102969 to six for Berhan (Table 3).

Figure 2 illustrates those genotypes ETSL102970, Berhan, and ETSL102969 had lower ASNPC values than other genotypes, indicating slower or less severe emergence of purple witchweed in these resistant sorghum genotypes. The cluster analysis grouped these genotypes into one group (Figure 3). Conversely, genotypes ETSL102957 and ETSL102944 exhibited higher ASNPC values, suggesting a higher incidence and more rapid emergence of purple witchweed around these susceptible genotypes. The resistant checks Berhan and Framida also demonstrated low ASNPC values, confirming their resistance to purple witchweed infestation. These findings further support the potential resistance of sorghum genotypes Berhan, ETSL102969, and ETSL102970 to purple witchweed infestation in Assosa, Benishangul Gumuz Region (Figures 1 and 3).

Validation Trials in Purple Witchweed Hot-Spot Farmer's Fields

As illustrated in Table 4, the validation trial confirmed that the fewest purple witchweed plants per plot emerged among the resistant check Berhan and the sorghum landrace ETSL102969. Additionally, fewer purple witchweed plants grew among the sorghum landrace ETSL102970 compared to the resistant check Framida. The number of purple witchweed plants per sorghum plant was also low among Berhan, ETSL102969, and ETSL102970 plants. Conversely, the largest number of purple witchweed plants grew among the susceptible checks ETSL102957 and Assosa-1. These findings indicate that Berhan, ETSL102969, and ETSL102970 exhibit strong resistance against purple witchweed infestation. Overall, this validation trial confirmed that ETSL102969 and ETSL102970 sorghum landraces have comparable or superior resistance to purple witchweed compared with resistant checks Berhan and Framida.

Furthermore, the promising sorghum landraces ETSL102969 and ETSL102970 demonstrated higher yields than the resistant checks in the validation trial. The larger seed size and white seed

Table 3. Response of sorghum landraces to purple witchweed in an artificially infested sick plot in 2022 at Assosa, Benishangul Gumuz, Ethiopia.[a,b]

Genotype	Sorghum parameters				Purple witchweed parameters		
	Days to flowering	Days to maturity	Plant height	Leaf number	Density	Plant height	Witchweed per sorghum
			cm	No.	No.	cm	No.
ETSL102969	99.0 k-m	144.0 c-h	101.96 j	3.45 h	3.5 c	26.34 ab	0.22 b
Berhan	98.0 lm	125.0 gh	139.79 h-j	5.87 b-h	3.0 c	36.63 ab	0.25 b
ETSL102970	73.0 n	142.0 d-h	121.91 j	3.95 gh	3.0 c	19.84 b	0.22 b
ETSL102975	116.0 h-j	157.0 a-g	207.78 b-j	9.65 a-d	7.5 c	30.03 ab	0.31 b
ETSC19001	134.0 d-g	161.5 a-g	151.04 g-j	5.30 d-h	7.5 c	22.08 ab	0.30 b
ETSL100053	152.0 bc	160.0 a-g	240.30 a-i	10.25 ab	7.5 c	38.33 ab	0.28 b
Framida	117.0 h-j	135.0 e-h	122.89 ij	5.89 b-h	8.0 c	28.69 ab	0.59 b
ETSL102976	130.0 d-h	180.5 a-d	234.36 a-i	8.90 a-f	11.5 c	32.05 ab	0.53 b
ETSL102955	152.0 bc	169.0 a-f	258.30 a-g	10.15 ab	14.0 c	29.01 ab	0.52 b
ETSL102949	114.0 h-l	154.0 a-g	242.95 a-i	7.91 a-g	14.5 c	30.31 ab	0.58 b
ETSL102925	119.0 g-j	168.0 a-f	265.10 a-g	11.22 a	15.0 c	28.86 ab	0.53 b
ETSC20006	116.0 h-j	160.0 a-g	209.70 b-j	9.11 a-f	17.5 c	29.35 ab	0.79 b
ETSL102896	136.5 c-f	159.0 a-g	244.97 a-i	11.81 a	18.5 c	38.57 ab	0.62 b
ETSC19002	99.0 k-m	152.0 b-g	220.33 a-j	11.55 a	19.0 c	26.01 ab	0.79 b
ETSC20002	94.0 m	150.0 c-g	154.70 g-j	9.83 a-c	19.5 c	93.44 a	0.72 b
ETSL102974	193.0 a	148.0 c-g	97.60 j	4.28 gh	20.0 c	29.77 ab	0.78 b
ETSL102951	124.0 e-i	169.0 a-f	171.86 c-j	11.25 a	21.5 c	33.05 ab	0.69 b
ETSC20003	91.0 m	146.0 c-h	161.45 f-j	9.60 a-e	22.5 c	26.07 ab	0.99 b
ETSC20005	123.0 e-i	158.0 d-l	201.65 b-j	10.55 a	23.0 c	22.72 ab	0.98 b
ETSC19003	115.0 h-k	159.0 a-g	161.70 f-j	8.83 a-f	23.5 c	39.00 ab	1.16 ab
ETSC20004	152.0 bc	194.5 ab	313.00 a	10.78 a	23.5 c	31.14 ab	0.86 b
ETSC19004	119.0 g-j	155.0 a-g	198.47 b-j	10.40 a	24.0 c	30.67 ab	1.19 b
ETSL102904	126.0 d-i	169.0 a-f	267.30 a-f	9.75 a-c	25.0 c	29.84 ab	1.25 ab
ETSL102956	119.0 g-j	186.0 a-c	276.84 a-e	9.72 a-d	25.0 c	93.35 a	0.99 b
Assosa-1	142.0 b-d	177.0 a-e	127.85 ij	10.71 a	25.5 c	27.88 ab	0.97 b
ETSL102920	157.0 b	173.0 a-f	289.61 a-d	10.90 a	28.0 c	26.85 ab	0.95 b
Adukara	130.0 d-h	176.0 a-f	163.85 e-j	11.17 a	48.5 bc	33.79 ab	1.51 ab
ETSL102940	115.0 h-k	134.0 f-h	194.57 b-j	10.85 a	49.5 bc	26.83 ab	2.47 ab
ETSL102947	120.0 f-i	105.0 h	303.75 a	12.08 a	58.0 bc	29.02 ab	4.14 a
ETSL102919	125.0 e-i	169.0 a-f	222.09 a-j	10.59 a	58.0 bc	36.19 ab	2.73 ab
ETSL102912	122.0 e-i	171.0 a-f	258.09 a-g	10.68 a	62.0 bc	35.24 ab	1.94 ab
ETSL102918	152.0 bc	165.0 a-g	292.84 a-c	10.99 a	64.5 b	34.89 ab	2.27 ab
ETSL102957	154.0 b	167.0 a-g	244.92 a-i	10.74 a	95.5 ab	27.71 ab	4.81 a
ETSL102954	137.0 c-e	163.0 a-g	241.72 a-i	11.09 a	104.5 a	28.08 ab	5.48 a
ETSL102944	124.0 e-i	196.0 a	249.90 a-h	11.05 a	148.5 a	24.13 ab	5.11 a
Mean	124	160.13	216.85	9.35	33.54	31.81	1.61
Tukey's MSD	16.55	42.68	127.74	4.44	61.57	72.60	4.02
CV	3.14	6.27	13.64	11.16	58.37	59.24	58.37

[a]Abbreviations: CV, coefficient of variation; MSD, minimum significant difference.
[b]Means within the same column followed by the same letter are not statistically different according to Tukey's MSD (α = 0.05).

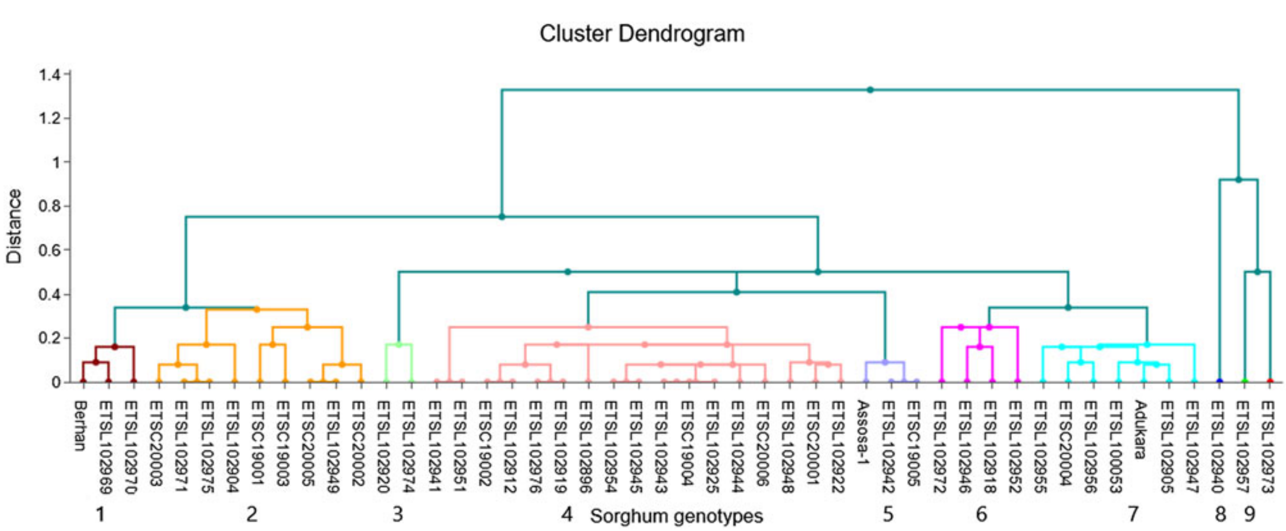

Figure 3. Cluster analysis showing the relationship among sorghum genotypes for their resistance to purple witchweed at Assosa, Ethiopia.

https://doi.org/10.1017/wet.2025.21

Table 4. Validation of purple witchweed-resistant sorghum landraces in farmers' fields in 2023 at Assosa, Benishangul Gumuz, Ethiopia.[a,b]

Genotypes	Purple witchweed per plot at 13 WACE	Sorghum plant height	Days to flowering	Purple witchweed per sorghum	Yield
	No.	cm		No.	t ha^{-1}
Berhan	47.30 d	117.00 c	74.33 d	1.01 b	1.77 c
ETSL102969	51.70 d	117.93 c	81.00 c	2.45 b	3.84 a
ETSL102970	136.33 cd	196.00 a	81.00 c	2.51 b	3.53 ab
Framida	267.67 cd	173.60 ab	86.67 b	12.06 ab	3.14 a-c
ETSL102975	529.70 c	116.87 c	155.00 a	30.05 a	3.81 a
Assosa-1	1156.33 b	133.27 bc	157.00 a	13.72 a	2.29 bc
ETSL102957	1638.33 a	140.53 bc	155.33 a	17.68 a	2.11 bc
Mean	546.76	142.17	112.91	11.26	2.93
Tukey's MSD	460.24	50.57	2.15	27.54	1.67
CV	19.08	12.45	3.46	21.31	23.12
P-value	0.037	0.0006	<0.0001	0.022	0.05

[a]Abbreviations: CV, coefficient of variation; MSD, minimum significant difference.
[b]Means within the same column followed by the same letter are not statistically different according to Tukey's MSD ($\alpha = 0.05$).

color of sorghum landrace ETSL102969 are particularly desirable traits among local farmers (Alemu et al. 2024; Legesse et al. 2019). These traits are beneficial for breeding programs because they can be combined with the purple witchweed resistance trait to develop sorghum varieties with both resistance and preferred seed characteristics. Incorporating these traits into breeding programs increases the likelihood of obtaining F-generations with both white color and large seed size, along with resistance to purple witchweed. This approach will not only benefit farmers but also improve productivity and enhance market value for sorghum in the region.

Practical Implication

This research reveals that Berhan, ETSL102969, and ETSL102970 showed strong resistance against purple witchweed. Additionally, the white seed color and large seed size of ETSL102969; a trait highly preferred by farmers, make this genotype more suitable for the breeding program aimed at developing purple witchweed-resistant and locally preferred sorghum varieties to improve yields and food security in regions plagued with purple witchweed. Genotypes such as Berhan, ETSL102969, and ETSL102970, when incorporated into breeding programs, could lead to more robust and resistant sorghum crops, thereby benefiting farmers in purple witchweed-affected regions.

Acknowledgments. We thank staff members of the Assosa Agricultural Research Center for providing a vehicle for collecting purple witchweed seeds, and for helping with field work.

Funding. Funding for this research was provided by the Ethiopian Institute of Agricultural Research.

Competing Interests. The authors declare they have no conflicts of interest.

References

Addisu S, Feleke G (2021) Distribution and importance of *Striga hermonthica* on tef [*Eragrostis tef* (Zucc.) trotter] in Tigray regional state of Ethiopia: a preliminary survey. Int J Agric Biosci 10:69–73

Alemu H, Begna F, Bekele D (2024) Improved sorghum technologies are vital in ensuring food security: The case of Benishangul Gumuz Region, Ethiopia. World J Food Sci Technol 8(4):126–133

Atera E, Itoh K (2011) Evaluation of ecologies and severity of *Striga* weed on rice in sub-Saharan Africa. Agric Biol J N Am 2:752–760

Atera EA, Itoh K, Azuma T, Ishii T (2012) Farmers' perspectives on the biotic constraint of *Striga hermonthica* and its control in western Kenya. Weed Biol Manag 12:53–62

Ayana TT, Bantte K, Tadesse T (2019) Evaluation of Ethiopian sorghum [*Sorghum bicolor* (L.) Moench] landraces: low germination stimulant genotypes for *Striga hermonthica* resistance under field condition. Adv Crop Sci Technol 7:444

Bayable D, Di Marcantonio F (2013) Analysis of incentives and disincentives for sorghum in Ethiopia. MAFAP Technical Notes Series. Rome: Food and Agriculture Organization of the United Nations

Degebasa L, Tessema T, Bekeko Z, Belete K (2022) Prevalence and socioeconomic impact of Striga (*Striga hermonthica*) in sorghum producing areas of east and west Hararghe zones, Oromia, Ethiopia. Int J Agron 2022(1):8402280.

Ejeta G, Babiker A, Butler L (1993) New approaches to the control of Striga Research at Purdue University. West Lafayette, IN: Agricultural Experiment Station, Purdue University.

Ejeta G, Gressel J (2007) Integrating new technologies for *Striga* control: towards ending the witch-hunt. Singapore: World Scientific Publishing Co. Pte. Ltd.

Franke AC, Ellis-Jones J, Tarawali G, Schulz S, Hussaini MA, Kureh I, White R, Chikoye D, Douthwaite B, Oyewole BD, Olanrewaju AS (2006) Evaluating and scaling-up integrated *Striga hermonthica* control technologies among farmers in northern Nigeria. Crop Prot 25:868–78

Gebreslasie A, Tessema T, Hamza I, Nigussie D (2016) Abundance and distribution of *Striga* (*Striga hermonthica* (Del.) Benth.) infestation in selected sorghum (*Sorghum bicolour* L. Moench) growing areas of Tigray Region, Ethiopia. Afr J Agric Res 11:4674–4682

Gethi JG, Smith ME (2004) Genetic responses of single crosses of maize to *Striga hermonthica* (Del.) Benth and *Striga asiatica* (L.) Kuntze. Crop Sci 44: 2068–2077

Haussmann BIG, Hess DE, Reddy BVS, Welz G, Geiger HH (2012). Analysis of resistance to *Striga hermonthica* in diallel crosses of sorghum. Euphytica 116:33–40

Haussmann BIG, Hess DE, Welz HG, Geiger HH (2000) Improved methodologies for breeding striga-resistant sorghums. Field Crop Res 66:195–211

Hearne SJ (2009) Control—the Striga conundrum. Pest Manag Sci 65:603–614

Kountche BA, Al-Babili S, Haussmann BI (2016) Striga: a persistent problem on millets. Pages 173–203 *in* Biotic Stress Resistance in Millets. Cambridge, MA: Academic Press

Legesse T, Demelash H, Seyoum A (2019) Participatory variety selection for enhanced promotion and adoption of improved sorghum [*Sorghum bicolor* (L) Moench] varieties for the humid lowland of Assosa Zone, Western Ethiopia. Sci Res Rev 12:104

Mandumbu R, Mutengwa C, Mabasa S, Mwenje E (2019) Challenges to the exploitation of host plant resistance for *Striga* management in cereals and legumes by farmers in sub-Saharan Africa: a review. Acta Agric Scand Sect B 69:82–88

Matusova R, Rani K, Verstappen FWA, Franssen MCR, Beale MH, Bouwmeester HJ (2005) The strigolactone germination stimulants of the plant-parasitic *Striga* and *Orobanche* spp. are derived from the carotenoid pathway. Plant Physiol 139:920–934

Mesfin AH, Girma F (2022) Understanding sorghum farming system and its implication for future research strategies in humid agro-ecologies in Western Ethiopia. J Agric Food Res 10:1–11

Mohamed KI, Musselman LJ (2008) Evolution and taxonomy of agronomically important *Striga* and *Orobanche* species. Pages 7–14 in Progress on Farmer Training in Parasitic Weed Management, R Labrada ed. Rome: Food and Agriculture of the United Nations Plant Production and Protection Division

Omanya GO, Haussmann BIG, Hess DE, Reddy BVS, Kayentao M, Welz HG, Geiger HH (2004) Utility of indirect and direct selection traits for improving *Striga* resistance in two sorghum recombinant inbred populations. Field Crop Res 89:237–252

Oswald A (2005) *Striga* control technologies and their dissemination. Crop Prot 24:333–342

Parker C (2009) Observations on the current status of *Orobanche* and *Striga* problems worldwide. Pest Manag Sci 65:453–459

Parker C (2012) Parasitic weeds: a world challenge. Weed Sci 60:269–276

R Core Team 2023. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing,

Rodenburg J, Demont M, Zwart SJ, Bastiaans L (2016) Parasitic weed incidence and related economic losses in rice in Africa. Agric Ecosyst Environ 235: 306–317

Spallek T, Mutuku M, Shirasu K (2013) The genus *Striga*: a witch profile. Mol Plant Pathol 14:861–869

Tesso T, Gutema Z, Derassa A, Gebisa E (2007) An integrated *Striga* management option offers effective control of *Striga* in Ethiopia. Singapore: World Scientific