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Research Article

Evaluation of sesame (*Sesamum indicum* L.) Varieties for Seed Yield and Yield Components under Bacterial Blight (*Xanthomonas campestris* pv. *sesami*) Disease Pressure in Western Tigray, Northern Ethiopia

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ABSTRACT

Yield reduction in sesame production in Ethiopia has been attributed to many biotic and abiotic factors. From among the biotic factors, bacterial blight (*Xanthomonas campestris* pv. *sesami*) disease is a major constraint across the major sesame growing areas. A study was conducted on farmers' field at Dansha (northern Ethiopia), "hot spot area" for bacterial blight disease, to identify the level of resistance to bacterial blight disease in some sesame varieties and assess the corresponding productivity of the varieties under natural disease pressure. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Highly significant differences ($p<0.01$) were observed in days to 50% flowering and maturity, number of branches and capsules per plant, plant height, seeds per capsule, 1000-seed weight, yield (kg/ha), oil content (%) percentage severity index (%) and AUDPC values. The mean maximum yield (651.7 kg/ha) was obtained from variety Gida-Ayana whereas, the lowest mean grain yield (428.3 kg/ha) was obtained from variety Hirhr. Variety Gida-Ayana had the lowest disease development and had the highest seed yield and percent oil content than the rest of the varieties tested. Thus, variety Gida-Ayana is identified as the most promising variety to be produced in the bacterial blight problem areas of northern Ethiopia.

Keywords: AUDPC; Sesame bacterial blight; Gida-Ayana; grain yield; PSI

INTRODUCTION

Sesame (*Sesamum indicum* L.), locally called "Selit" or "Simsim," is one of the major economically important oil crops and the second major source of foreign currency, next to coffee, in Ethiopia [1]. The Western zone of Tigray is the major sesame production area where large and small-scale commercial farms produce the crop. Sesame is an important source of livelihood for more than four million smallholder farmers [2]. Nevertheless, the productivity of sesame has remained very low mainly due to both biotic and abiotic factors including diseases [3]. From among the diseases, bacterial leaf blight caused by *Xanthomonas campestris* (Pammel) Dawson pv. *Sesami* has gained substantial economic importance in the country, causing heavy losses on sesame production [4]. The disease is known to cause losses of about 60% capsule and 25-40% seed yield in Egypt [5], 21-27% seed yield in India [6] and under rainy and humid conditions, complete crop failure in the Sudan and Ethiopia [7,8].

Due to the low degree of genetic variability among sesame accessions and breeding lines under production in Ethiopia, bacterial blight resistant sesame materials are rarely available though some level of variation among breeding lines, in resistance or tolerance to the bacterial disease, exists. Determining the degree of tolerance/resistance in existing sesame varieties and breeding lines to the bacterial blight disease would contribute to the identification of materials that are relatively tolerant/ resistant to the disease and that can serve as good parental sources for future resistance breeding programs against the disease. Therefore, this study was carried out to evaluate some sesame varieties for their resistance/ tolerance to the disease under natural infection at Dansha (Kebabo), northern Ethiopia, hot spot for bacterial blight disease infection.

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MATERIALS AND METHODS

Description of the study area

The experiment was conducted at Dansha (Kebabo) under natural infection during the 2018 cropping season. The site is located at 13° 38' 306" North latitude and 36° 52' 84.1" East longitude and at an altitude of 747 m.a.s.l. The mean annual rainfall and mean annual temperature of the area is 888.4°C mm and 28.7°C, respectively.

Treatment and experimental design

To aid the natural disease infection and development, the experiment was conducted on a field that was planted to sesame and had severe bacterial blight disease in the previous year. Three improved and two local varieties of sesame (Table 1) were used in the study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and plot size of 9 m2 (3.6 m width by 2.5 m length). The sesame seeds were planted in rows with row to row and plant to plant distance of 40 cm and 10 cm, respectively. Urea fertilizer at the rate of 50 kg/ha was applied in split applications (half at sowing and half before flowering) while DAP (100 kg/ha) fertilizer was applied only at sowing time.

Table 1: Description of sesame varieties used in the experiment.

No	Varieties	Sources	Year of release	Seed color
1	Gida-Ayana	ASARC	2018	White
2	Setit-2	HUARC	2016	White
3	Humera-1	HUARC	2011	White
4	Gojam-Azene	Local	-	White
5	Hirhir	Local	-	White

Disease development

Bacterial blight disease severity was recorded from 10 randomly selected and marked (pre-tagged) plants from the middle rows of each plot (Table 2). Bacterial blight disease severity on the leaves was measured six times every seven days interval using a disease rating scale [9] where:

Table 2: Bacterial blight disease severity on the leaves.

Scale	Percent of infection	Category
0	0%	Immune
1	0.1-5%	Highly Resistant
2	5.1-10%	Resistant
3	10.1-20%	Moderately Resistant
4	20.1-50%	Moderately Susceptible
5	50.1-70%	Susceptible
6	> 70 %	Highly Susceptible

The severity grades were converted to percentage severity index (PSI) using the following formula for analysis [10].

$$PSI = \frac{Sum\ of\ individual\ numerical\ ratings}{\text{Total number of plants assessed} \times \text{Max. Score in scale}} \times 100$$

Area under the Disease Progress Curve (AUDPC) was also calculated using the formula given by Campbell and Madden [11].

$$\textbf{AUDPC} = \sum_{i=1}^{n-1} 0.5\left(x_{i+1} + x_i\right)\left(t_{i+1} - t_i\right)$$

Where x_i is the severity percentage of the disease at i_{th} assessment, t_i is the time of the i_{th} assessment in days from the first assessment date and n is the total number of disease assessment. The AUDPC value is expressed in percent-days.

Data on days to 50% flowering and physiological maturity, Thousand seed weight (g), Grain yield (kg/ha) and Oil content (%) were collected from the middle rows in each plot. Plant height (cm), mean number of fertile capsules per plant, and mean number of seeds per capsule were recorded from ten randomly selected plants in each plot. The percent oil content of the seeds was determined from 40 gram samples taken from each plot by Nuclear Magnetic Resonance method.

Statistical analysis

Data on bacterial blight disease severity, AUDPC and the various agronomic data collected were subjected to analysis of variance (ANOVA) according to the Duncan Multiple Range Test (DMRT) using Gen Stat-18 statistical software programs and least significance difference (LSD) was used for the mean comparison at 5% and 1% probability level. Correlation analysis was used to examine the relationship between tested factors.

RESULTS AND DISCUSSION

Disease components

The level of bacterial blight disease development, as estimated using the Percentage severity index (PSI), was statistically highly significantly different ($P<0.01$) among the varieties across all assessment dates (Table 2). Symptoms of the disease were observed 48 days after planting across all varieties tested and the severity of the diseases increased afterwards (Figure 1) though the level of disease development varied among the varieties. The local sesame variety Hirhr had significantly higher PSI than the rest of the varieties except that of Humera-1 on the first date of assessment and significantly higher level of PSI than all varieties on subsequent assessment dates. Varieties Gida-Ayana and Gojam-Azene, though had statistically similar level of disease development on the first and second dates of assessment, both varieties had statistically lower level of PSI than the rest of the varieties. Considering the final assessment date, variety Hirhr had the highest PSI value (50.5) followed by Humera-1 (37.1) and Setit-2 (28.9). The lowest PSI value (9.98) was recorded from Gida-Ayana followed by that of Gojam-Azene (19.34) both of which had significantly lower PSI value than the rest of the varieties. This is a good indication that both Gida-Ayana and Gojam-Azene were able to keep the disease development at relatively lower level across the crop growth period.

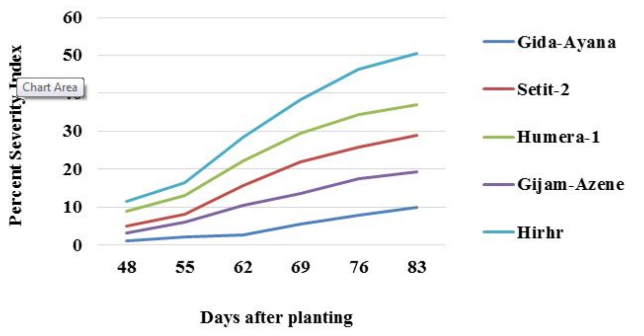

Figure 1: Percent severity index of bacterial blight disease among sesame varieties and across assessment dates.

Similar to the PSI, the area under disease progress curve (AUDPC) is a very convenient summary of plant disease epidemics that incorporates initial intensity, the rate parameter, and the duration of the epidemic, which determines the final disease intensity and it is known that AUDPC is directly related to the yield loss [12] Therefore, selection of sesame varieties with low AUDPC value would be acceptable for practical purposes.

In the current study, there was highly significant difference (P<0.01) among the varieties in the AUDPC values. The highest AUDPC value (1096.2%) was obtained from variety Hirhr followed by Humera-1 (838.2%), whereas, the lowest AUDPC (157.7%) was calculated from Gida-Ayana (Table 3). Though none of the varieties tested in the current study was immune, based on both PSI and AUDPC values, varieties Gida-Ayana and Gojam-Azene are considered as resistant and moderately resistant, respectively; Setit-2 and Humera-1 as moderately susceptible and Hirhr as susceptible (Table 2). [13,14] similarly reported that sesame varieties and genotypes they evaluated showed different levels of resistance to the disease with no completely resistant lines.

Table 3: Percentage Severity Index (PSI) and Area Under Disease Progress Curve (AUDPC) of bacterial blight disease on sesame varieties at Dansha (Kebabo) during 2018 cropping season.

Variety	Percentage severity index (%) of bacterial blight disease on different assessment dates						AUDPC (%-days)	Disease Reaction
	48	55	62	69	76	83		
Gida-Ayana	1.2^{b}	2.3^{c}	2.75^{e}	5.4^{e}	7.8^{e}	9.98^{e}	157.7^{e}	R
Sertit-2	5.1^{b}	8.1^{b}	15.7^{c}	21.8^{c}	25.8^{c}	28.9^{c}	603.3^{c}	MS
Humera-1	8.9^{a}	13.2^{a}	22.1^{b}	29.5^{b}	34.3^{b}	37.1^{b}	838.2^{b}	MS
Gojam-Azene	3.2^{a}	6.1^{bc}	10.4^{d}	13.5^{d}	17.5^{d}	19.34^{d}	397.5^{d}	MR
Hirhr	11.4^{a}	16.4^{a}	28.2^{a}	38.6^{a}	46.3^{a}	50.5^{a}	1096.2^{a}	S
LSD (<5%)	3.6	4	4	4.8	4.7	2.	92.3	
CV%	32.6	23	23.5	11.7	9.5	3.7	7.9	

Assessment dates are indicated in days after planting; AUDPC= area under disease progress curve; LSD= least significant difference; CV (%) = Coefficient of variation; R = resistant; MR= moderately resistant; MS= moderately susceptible; S = susceptible. Means of the same letters are not significantly different at 5% level of significance.

Agronomic (yield) components

There was highly significant differences (p<0.01) among varieties across the agronomic parameters considered in the current study. The variation in yield and yield components among the tested varieties was attributed to their genetic potential for yield and disease resistance. Both Gida-Ayana and Gojam-Azene were significantly late in flowering and physiological maturity than the remaining varieties. Varieties Gida-Ayana, Setit-2 and Gojam-Azene had statistically similar seed weight while variety Hirhr had significantly lower seed weight. Both Gida-Ayana and Gojam-Azene had oil content (53%) that was significantly higher than those of the rest of the varieties tested.

Variety Gida-Ayana had significantly higher yield (651.7 kg/ha) than the remaining varieties. The seed yield of Gojam-Azene (559.6 kg/ha) was statistically similar to those of Setit-2 (568.5 kg/ha) and Humera-1 (535.6 kg/ha). Despite the significantly higher bacterial blight disease load on varieties Setit-2 and Humera-1, the seed yield of these two varieties was statistically similar to that of Gojam-Azene, a moderately resistant variety. [15,16] had similar observations in which some moderately resistant groundnut genotypes they tested had the lowest yield (Table 4).

Table 4: Effect of bacterial blight disease on yield and yield components of sesame varieties at Dansha (Kebabo) during 2018 cropping season.

Variety	DF	DM	PH	BPP	TSW	SPC	CPP	Yield (kg/ha)	Oil content (%)
Gida-Ayana	55.3^{a}	111.0^{a}	121.6^{a}	4.0^{a}	2.3^{a}	72.9^{a}	53.6^{a}	651.7^{a}	52.8^{a}
Sertit-2	43.0^{b}	92.0^{d}	109.5^{ab}	3.8^{a}	2.1^{ab}	61.3^{ab}	47.0^{ab}	568.5^{b}	47.2^{c}
Humera-1	40.3^{b}	93.0^{cd}	87.8^{bc}	2.67^{b}	1.9^{b}	54.9^{b}	31.0^{cd}	535.6^{c}	50.2^{b}
Gojam-Azene	53.3^{a}	107.0^{b}	93.3^{bc}	2.9^{b}	2.0^{ab}	49.6^{b}	40.3^{bc}	559.6^{bc}	53.0^{a}
Hirhr	43.3^{b}	94.0^{c}	78.53^{c}	2.0^{c}	1.8^{b}	47.3^{b}	23.3^{d}	428.3^{d}	46.8^{c}
LSD (<5%)	4.9	1.6	23.7	0.6	0.3	15.2	9.9	28.7	2.2
CV%	5.6	0.9	12.8	10.3	8.9	14.1	13.5	2.8	2.3

DF=Days to 50% Flowering; DM=Days to 50% Maturity; PH= Plant Height (Cm); BPP=Branches Per Plant; TSW=1000-Seed Weight; SPC=Seed Per Capsule; CPP=Capsule Per Plant; LSD=Least Significance Difference; CV (%)=Coefficient of Variation; Means of the same letters are not significantly different at 5% level of significance.

Association of disease parameters with yield and yield components

Correlation analysis showed that, disease parameters (PSI and AUDPC) were significantly (P<0.01) correlated with yield and yield components of sesame (Table 5). Both PSI and AUDPC had strong and negative correlation with seed yield, plant height, thousand seed weight, and number of capsules and branches per plant while moderate negative correlation with the number of seeds per capsule. Similarly [17] found that yield and yield components were negatively correlated with area under disease progress curve of leaf spot diseases under more conducive conditions. [18,19] reported that seed yield in sesame is a function of capsule length, capsule per plant, and number of seeds per capsule and 1000-seed weight.

Table 5: Correlation coefficients (r) among AUDPC, PSI, yield and yield components of sesame varieties during 2018 cropping season.

Parameters	PH	BPP	CPP	SPC	TSW	Yield (kg/ha)	AUDPC
PH	-						
BPP	0.86**	-					
CPP	0.89**	0.91	-				
SPC	0.56*	0.65**	0.54*	-			
TSW	0.48^{ns}	0.67**	0.72**	0.54*	-		
Yield	0.82**	0.88**	0.9**	0.65**	0.69**	-	
AUDPC	-0.74**	-0.79**	-0.87**	-0.54*	-0.76**	-0.92**	-
PSI	-0.70**	-0.77**	-0.86**	-0.52*	-0.73**	-0.92**	0.98**

PH= Plant Height; BPP= Branch Per Plant; CPP= Capsule Per Plant; SPC= Seed Per Capsule; TSW= Thousand Seed Weight; AUDPC= Area Under Disease Progress Curve; PSI=Percentage Severity Index in the final assessment date; * and ** refers to mean square values significant and highly significant at p<0.05 and p<0.01 repectively; ns=Refers to mean square values not significant at p<0.05.

CONCLUSION

Variety Gida-Ayana, though not immune, had the lowest disease development (significantly lower PSI and AUDPC values) across the assessment dates than the rest of the varieties. It also had the highest seed oil content and seed yield. Thus the sesame variety Gida-Ayana would be the most promising variety for areas where the bacterial blight disease is severe, such as the low lands of Western Tigray, as it combines both good level of resistance to the bacterial blight disease and the best yield and seed oil content. The productivity of this particular variety could possibly be improved through the integration of other bacterial blight management practices. Thus, studies would be required to look for other alternative measures that would help enhance the productivity of the variety.

CONFLICTS OF INTEREST

The authors stated that no conflicts of interest.

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