

Evaluation of Different Fungicides for Effective Management of Powdery mildew (*Oidium sesami*) of Sesame (*Sesamum indicum* L.) in Southeastern Oromia; Bale, Ethiopia

Ermias Teshome*

Sinana Agricultural Research Center, Bale-Robe, Ethiopia

*Corresponding Author: Ermias Teshome, Sinana Agricultural Research Center, Bale-Robe, Ethiopia.

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Abstract

Sesame (*Sesamum indicum* L.) is a vital oil crop produced in the world and Ethiopia is one of the major producer countries of the crop. The Field experiment was conducted for two years (2015/16 and 2016/17 GC) at Delo-mena site of Sinana Agricultural Research Center (SARC) with the objective of identifying effective fungicide for the management of Powdery mildew of Sesame. The trial was arranged in RCB Design with three replications. The treatment fungicides were; Odeon 825 WDG, Mancozeb 80% WP, Natura 250 EW, Ridomil Gold MZ 68 WG, Rex[®] Duo, Tilt 250 EC and unsprayed control was included for treatment comparison. Disease severity was scored on 10 randomly pre-tagged plants from the central four rows. Area under the disease progress curve (AUDPC) and disease progress rate (r) were derived from percent disease severity index. Logistic model ($\ln[y/(1-y)]$) was employed to estimate the disease progression and data were analyzed using SAS procedure. The association of disease parameters with yield and yield related traits were assessed using Correlation and Regression analysis. ANOVA for disease severity (%), AUDPC (%-days) and r units⁻¹ day have shown statistically significant ($p < 0.01$) difference between treatments. The highest Powdery mildew disease severity of 40.33% and the lowest (5.67%) were recorded from unsprayed control and Tilt 250 EC treated plots, respectively. Similarly, the highest AUDPC (1445.50%-days) and r (0.03703 units-1day) and the lowest AUDPC (193.67%-days) and r (-0.00414 units-1day) were similarly calculated from unsprayed control and Tilt 250 EC treated plots, respectively. Regarding yield and yield related traits; ANOVA has shown significant variations ($P < 0.01$) between treatments for number of Capsules per plant, Capsule length, TKW and grain yield. The highest number of Capsules per plant (71.67), Capsule length (3.01 mm), TKW (3.27g) and grain yield (618.98 kg/ha) were recorded from a plot sprayed with Tilt 250 EC treated plot; while the lowest number of Capsule per plant (21.33), Capsule length (2.30 mm), TKW (2.80g) and grain yield (457.87 kg/ha) were recorded from unsprayed control plot. Simple linear regression of TKW and grain yield with Powdery mildew disease severity and AUDPC have revealed significant association ($P < 0.01$) between treatments. Pair wise pearson correlation analysis has showed significant ($P < 0.01$) correlation between disease parameters and yield parameters. The correlation between grain yield with Powdery mildew disease severity and AUDPC have depicted that Powdery mildew disease severity and AUDPC have strong negative correlation with grain yield ($r = -0.91927$) and ($r = -0.91951$), respectively. Therefore, based on the result of this study, a fungicide Tilt 250 EC is recommended for the management of Powdery mildew disease on Sesame at both small and large-scale production levels.

Keywords: Sesame; Powdery Mildew; Disease Severity Index; AUDPC; Disease Progress Rate and Disease Progress Curve

Background and Justification

Sesame (*Sesamum indicum* L.) is a vital oil crop produced in the tropical and subtropical parts of the World [1] and Ethiopia is one of the major producer countries of sesame in the World. In Ethiopia, during 2015/16 cropping season, sesame was produced on an area of 388,245.50 ha of land with a total production of 274,217.43 tons [2]. While area of land covered by the crop in Oromia Region was about 58, 202.10 ha with a total production of 45,485.11 tons [2]. The crop is endowed with diverse natural gift, of which users can

benefit. Seed from sesame is rich in oil (50 - 52%), protein (17 - 19%) and carbohydrates (16 - 18%) [3].

During 2016 cropping season, national sesame productivity was 0.7 tons per hectare [2]. This is far less than Global average which is 2.25 tons per hectare [4]. Diseases are reported to cause a considerable yield loss elsewhere in the World [5]. Powdery mildew and leaf spot are important fungal diseases which were reported to cause a yield loss of 45% - 100% and 22 - 53%, respectively during severe epidemics. However, regardless of the economic impor-

tance of these diseases in Bale zone; there is no any effort made for its management. Therefore, this experiment is intended to evaluate some fungicides and recommend for the end users which will take us one step forward in the management of this disease.

Materials and Methods

Description of Experimental Site

This experiment was conducted for two years in 2015/16 and 2016/17 GC during the main cropping season of Delo-mena area, Bale at Sinana Agricultural Research Center (SARC) sub-site. SARC is located at 7°7' N (latitude) and 40°10' E (longitude) at about 2400 m.a.s.l and receives 750 - 1000 mm mean annual rain fall and a mean annual temperature of 9 - 21°C [6]. The location represents the mid-land areas of major Sesame producing area. The area is a hot spot environment for the development Powdery mildew (*Oidium sesami*) disease of Sesame.

Treatments and Design

The experiment was executed using Randomized Complete Block Design with three replications. Local Sesame cultivar was used to evaluate the effectiveness of different fungicides against Powdery mildew disease of sesame (Table 2). A plot size was 3m x 2.4 m and between row, plot and replication spacing of 0.4m, 2m and 2m, respectively was used. Disease infection gradient was created by spraying test fungicides at a rate of their normal pathological studies recommendation. Fungicides sprays were started immediately after about 10 - 15% disease development was observed on leaves and the sprays were continued at seven (7) days interval and sprayed three (3) times (Table 2). A powdery mildew disease development was rated (Table 1) based on a scoring scale developed for the disease on a 0 - 9 scale [7].

Disease Grade	Grade Description
0	No lesions or specks
1	Small sized powdery specks infecting less than 1% leaf area
3	Enlarged irregular powdery growth covering 1 - 5% leaf area
5	Powdery growth to form big patches covering 5 - 25% leaf area
7	Powdery growth covering 25 - 50% leaf area followed by yellowing
9	100% leaf area covered with powdery growth, yellowing and dropping of infected leaves

Table 1: Disease scoring scale for Powdery mildew disease of sesame.

Untreated plot (Control) which has not received a fungicide spray was included as check for treatment comparison. Seed rate of 4 kg/ha was used based on the recommendation and other agronomic management packages like fertilizer rate, weeding and other are applied as per the recommendation as non-experimental variable.

No.	Test fungicides		Application rate
	Trade Name	Common Name	
1	Odeon 825 WDG	Chlorothalonil	2.5 kg/ha
2	Mancozeb 80% WP	Mancozeb	2.5 kg/ha
3	Natura 250 EW	Tebuconazole	0.65 l/ha
4	Ridomil Gold MZ 68 WG	Metalaxyl-M	2.5 kg/ha
5	Rex® Duo	Epoxiconazole + Thiophanate-methyl	0.5 l/ha
6	Tilt 250 EC	Propiconazole	0.5 l/ha
7	Untreated Control	NA	NA

Table 2: List of Fungicides and Treatment Arrangement of the Trail.

Note: NA: Not Applicable

Data Management and Statistical Analysis

Logistic, $\ln \left[\frac{Y}{1-Y} \right]$, (Vander Plank 1963) and Gompertz, $-\ln[-\ln(Y)]$ [8] models were compared for estimation of disease parameters from each treatment. The goodness of the fit of the models was tested using coefficient of determination (R^2) and Logistic model was found to fit best for the current study. Therefore, Independent variables for field experiment data under different treatments were analyzed using logistic model, $\ln \left[\frac{y}{1-y} \right]$ with the SAS Procedure [9]. The slope of the regression line was used to estimate the disease progress rate in different treatments. Disease severity was recorded in 1 to 7 scale where, 1= 0 - 14%, 2 = 14.1 - 29%, 3 = 29.1 - 43%, 4 = 43.1 - 57% and 5 = 57.1 - 71%, 6 = 71.6 - 86% and 7 = 86.1 - 100% of the leaf area damaged by the disease and disease incidence will be recorded in percentage per plot. The disease data recorded based on scale mentioned above was converted in to percentage severity index (PSI) according to Wheeler [10]. AUDPC values were calculated for each plot using the standard formula [11] based on PSI calculated and ANOVA was performed for disease severity index [10], AUDPC [11], and rate of

disease progress (r) accordingly. The association of disease parameters with yield and yield related parameters was assessed using Correlation and regression analysis. Mean separation was made based on LSD technique at 5% probability level.

$$PSI = \frac{\text{Sum of Numerical Ratings X 100}}{\text{Number of Plants Scored X Maximum Score on Scale}} \dots\dots\dots 1$$

$$AUDPC = \sum_{i=1}^{n-1} 0.5(x_{i+1} + x_i)(t_{i+1} - t_i) \dots\dots\dots 2$$

Where, X_i = the PSI of disease at the i^{th} assessment
 t_i = is the time of the i^{th} assessment in days from the first assessment date
 n = total number of disease assessments

Result and Discussions

The combined Analysis of variance over years have shown that there were statistically significant variations across treatments for disease parameters such as Powdery mildew disease severity (%), Area Under Disease Progress Curve (AUDPC) (%-days) and Disease Progress Rate (r) (units day⁻¹) (Table 3). Similarly, in case of yield and yield related parameters such as Percent stand, No. of Capsules per plant, Capsule length (mm), Plant height (cm), TKW (g), and Grain yield (kg/ha) (Table 4) the difference among treatments is statistically justifiable. For diseases severity (%) statistically significant difference (P < 0.01) was observed among the treatments evaluated. The highest Powdery mildew disease severity (40.33%) was recorded from a plot without fungicide treatment (untreated control), while the lowest disease severity of 5.67% was recorded from a plot sprayed with a fungicide Tilt 250 EC (Figure 1 and Table 3). This result is in agreement with some studies where both synthetic and botanical fungicides reduced *Cercospora* leaf spot disease severity on sesame [3]. Similarly, it was reported that the intensity of *Cercospora* leaf spot was significantly reduced by the effect of a fungicide treatment as compared untreated crop [12].

In the same way, statistically significant differences (P < 0.05) was observed for AUDPC and disease progress rate (r). The highest AUDPC of 1445.50%-days and the lowest 193.67%-days were calculated from non-treated plot and a plot sprayed with Tilt 250 EC fungicide, respectively (Table 3). The result this study agrees with Nahunnaro and Tunwari [12] result in that the fungicide treatment has significantly reduced the disease progress curve. Similarly, the highest and the lowest Powdery mildew disease progress rate (r) of 0.03703 and -0.00482 units-day⁻¹, respectively were calculated from non-treated plot and a plot sprayed with Mancozeb 80% WP fungicide, respectively.

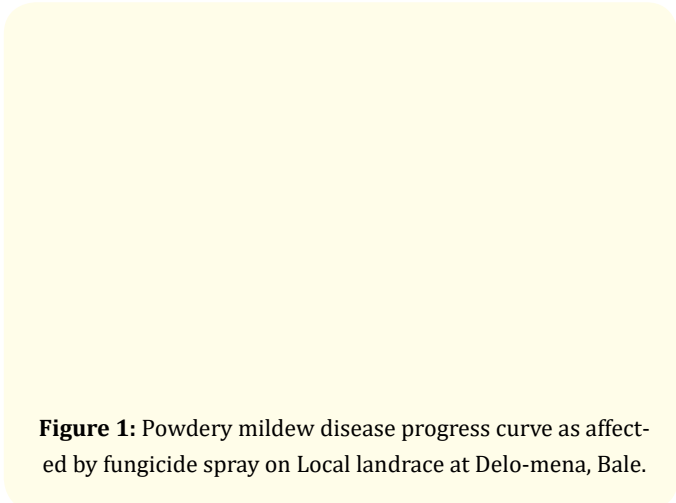


Figure 1: Powdery mildew disease progress curve as affected by fungicide spray on Local landrace at Delo-mena, Bale.

Treatment	Disease Severity (%)	AUDPC (%-days)	r (units-day ⁻¹)
Untreated Control	40.33	1445.50	0.03703
Odeon 825 WDG	7.39	260.17	-0.00327
Ridomil Gold MZ 68 WG	6.94	239.17	-0.00466
Rex [®] Duo	7.50	260.17	-0.00475
Mancozeb 80% WP	8.17	283.50	-0.00482
Natura 250 EW	6.83	235.67	-0.00433
Tilt 250 EC	5.67	193.67	-0.00414
CV (%)	15	13.62	11.46
LSD (p≤0.05)	4.55	25.44	0.00321

Table 3: Effect of Fungicide application on Powdery mildew Disease Severity (%), AUDPC (%-days) and Disease Progress Rate (r).

Note: AUDPC-Area Under Disease Progress Curve; r-Disease Progress rate.

With regard to yield and yield related parameters, the maximum number of Capsules per plant (71.67) and the highest Capsule length (3.01 mm) were recorded from a plot sprayed with a fungicide Tilt 250 EC; while the smallest Capsule per plant (21.33) and Capsule length (2.30) were recorded from unsprayed plots (Table 4). Similarly, the highest plant height (144.89 cm) and the highest TKW (3.27g) were recorded from a plot sprayed with a fungicide Tilt 250 EC; while the lowest plant height of 114.22 cm and the lowest TKW of 2.80 g were recorded from unsprayed plot (Table 4). Similarly, it was reported by Tunwari and Nahunnaro [13], that during their study they have found that the fungicides significantly influenced both yield and yield components positively. Likewise,

the highest grain yield of 618.98 kg/ha were recorded from a plot treated with a fungicide Tilt 250 EC; while the lowest grain yield of 457.87 kg/ha was recorded from a plot with no fungicide treatment (unsprayed control) (Table 4). All the tested fungicides have

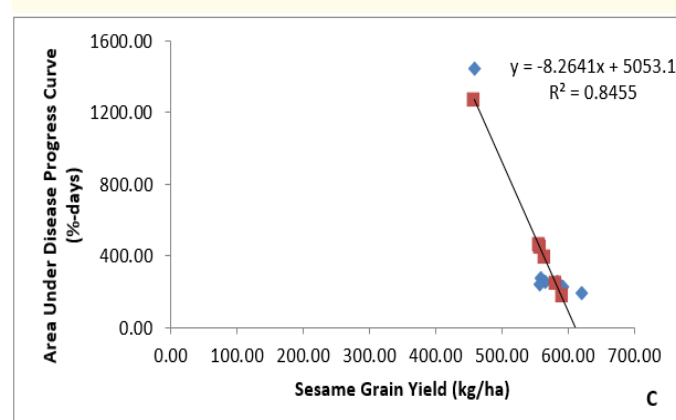
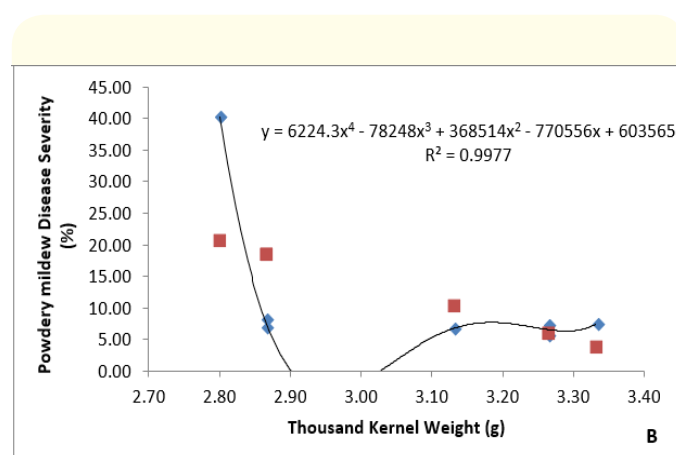
shown an overall efficacy over *Cercospora* leaf spot of Sesame in this trial. This result is supported by Enikuomehin [14] when they found similar result from their study.

Treatment	% Stand	No. Capsule/plant	Capsule length (mm)	Plant height (cm)	TKW (gm)	Grain yield (kg/ha)
Unsprayed Control	75.00	21.33	2.30	114.22	2.80	457.87
Odeon 825 WDG	81.67	57.11	2.41	119.56	3.27	564.40
Ridomil Gold MZ 68 WG	86.67	59.56	2.35	133.89	2.87	555.67
Rex® Duo	88.33	62.11	2.77	117.78	3.33	581.57
Mancozeb 80% WP	86.67	54.12	2.54	133.89	2.87	558.43
Natura 250 EW	88.33	66.56	2.79	142.78	3.13	590.51
Tilt 250 EC	90.00	71.67	3.01	144.89	3.27	618.98
CV (%)	10.45	16.50	12.14	9.47	8.05	22.47
LSD _(p<0.05)	7.85	19.74	0.39	21.28	0.29	148.78

Table 4: Yield and Yield Components of Sesame as Influenced by the Fungicide Application against Powdery mildew disease.

Note: TKW-Thousand Kernel Weight.

Accordingly, the simple linear regression analysis result has revealed that there is not statistically significant ($t = -1.499$, $p = 0.1942$, $R^2 = 0.31$ and $df = 1,6$) linear association between Powdery mildew disease severity and Sesame thousand kernels weight and there is not statistically significant ($t = -1.493$, $p = 0.1957$, $R^2 = 0.3083$ and $df = 1,6$) linear association between Powdery mildew disease AUDPC and Sesame thousand kernels weight. On the other hand, there is very strong polynomial association between disease severity and thousand kernels weight ($R^2 = 0.9977$) (Figure 2B) and AUDPC and thousand kernels weight ($R^2 = 1$) (Figure 2D). In contrary, there is strong linear relationship between disease severity and Sesame grain yield ($t = -5.22$, $p < 0.01$, $R^2 = 0.8451$ and $df = 1,6$) (Figure 2A) and between AUDPC and Sesame grain yield ($t = -5.2309$, $p < 0.01$, $R^2 = 0.8455$ and $1,6$) (Figure 2C).



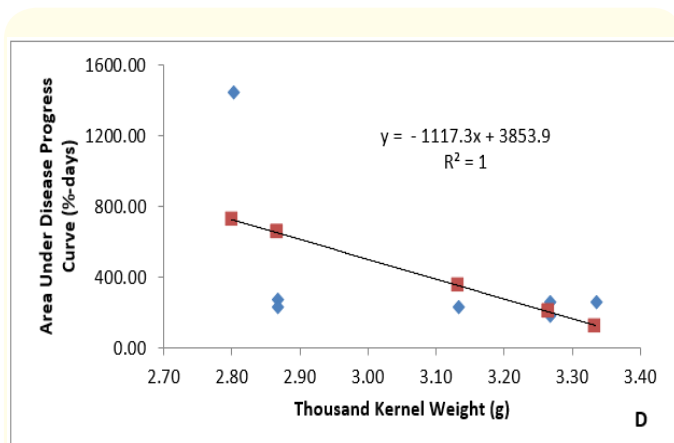


Figure 2: Estimated relationship between Powdery Mildew Disease Severity and Sesame Grain Yield (A), Powdery Mildew Disease Severity and Sesame Thousand Kernel Weight (B), Powdery Mildew Disease Area Under Disease Progress Curve and Sesame Grain Yield (C) and Powdery Mildew Disease Area Under Disease Progress Curve and Sesame Thousand Kernel Weight (D).

Likewise, pair wise Pearson correlation analysis was employed to assess the degree of association between Powdery mildew disease parameters and yield and yield related traits of Sesame. Accordingly, there is statistically significant correlation ($P < 0.01$) between disease parameters and yield parameters with different degree of correlation. Powdery mildew disease severity has very strong negative correlation with number of Capsules per plant ($r = -0.95240$) and grain yield ($r = -0.91927$). Similarly, Percent crop stand has strong negative correlation with Powdery mildew disease severity ($r = -0.87840$) (Table 5). Likewise, significant strong negative correlation ($r = -0.87993$, $r = -0.95274$ and $r = -0.52359$) were found between AUDPC and Percent crop stand, number of Capsules per plant and Capsule length, respectively. Significant positive correlations were also found between disease parameters themselves and between yield and yield related parameters themselves as well (Table 5). Sesame grain yield was found to have very strong significant positive correlation with percent crop stand, Number of capsules per plant and Capsule length having correlation coefficient (r) values of $r = 0.92384$, $r = 0.98685$, $r = 0.80234$, respectively (Table 5).

	Disease Severity (%)	AUDPC (%-days)	r (units ⁻¹ day)	% stand	No. capsule/plant	Capsule length (mm)	Plant ht (cm)	TKW (g)	Yield (kg/ha)
Disease Severity (%)	1.00000								
AUDPC (%-days)	0.99999	1.00000							
r (units ⁻¹ day)	0.99705	0.99713	1.00000						
% stand	-0.87840	-0.87993	-0.87533	1.00000					
No. capsule/plant	-0.95240	-0.95274	-0.93312	0.93409	1.00000				
Capsule length (mm)	-0.52255	-0.52359	-0.49459	0.76580	0.72205	1.00000			
Plant ht (cm)	-0.57606	-0.57788	-0.55131	0.72806	0.68575	0.60276	1.00000		
TKW (g)	-0.55682	-0.55525	-0.52475	0.48471	0.65590	0.67865	0.06920	1.00000	
Yield (kg/ha)	-0.91927	-0.91951	-0.89711	0.92384	0.98685	0.80234	0.67792	0.71323	1.00000

Table 5: Pair wise Pearson correlation coefficients among disease parameters, yield and yield Components of Sesame.

Note: AUDPC- Area Under Disease Progress Curve (%-days); r- Disease Progress Rate (units⁻¹day); % Stand- Percent plot Stand; TKW- Thousand Kernels Weight

Conclusion and Recommendation

Sesame (*Sesamum indicum* L.) is an important oil crop produced in the tropical and subtropical parts of the World. Likewise, Ethiopia is one the major Sesame producer countries. In Ethiopia, during 2010/11 cropping season, sesame was produced on an area of 384,682.79 ha of land with total production of 3,277,409.22 quintals which increased by about 25.8% from that of 2009/10 production year (CSA, 2011). Currently, in the humid midland areas of Bale

there is a wide expansion of Sesame production. And farmers of this area are producing the crop intensively due to its high market value. However, farmers are suffering from a huge productivity loss due to Powdery mildew disease of Sesame. This disease is challenging the crop productivity putting its production highly under its potential. To tackle this problem, different fungicides supposed to control/reduce the diseases are evaluated in Delo-mena district of Bale zone. All the evaluated fungicides have shown an effectiveness as compared to the control plot against the disease.

However, out of the tested fungicides Tilt 250 EC has showed better controlling potential against the disease. Therefore, Tilt 250 EC is recommended for use against Powdery mildew disease of Sesame.

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