



## THE EFFECT OF VARIETIES AND FUNGICIDE SPRAY FREQUENCIES ON SEPTORIA LEAF BLOTCH (*Mycosphaerella graminicola*) EPIDEMICS ON BREAD WHEAT IN WESTERN AMHARA, ETHIOPIA

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### ABSTRACT

#### Article History

Received: 19 August 2019

Revised: 23 September 2019

Accepted: 25 October 2019

Published: 27 November 2019

#### Keywords

AUDPC

Bread wheat

Disease progress rate

Epidemics

Fungicide

Septoria leaf blotch

Spray frequency.

Bread wheat (*Triticum aestivum* L.) is one of the most important small grain cereals produced worldwide. Despite its economic significance, wheat production and productivity is challenged by biotic and abiotic factors. Septoria leaf blotch (*Mycosphaerella graminicola*), is among the most important pathogens that inflict qualitative and quantitative losses on susceptible wheat varieties in the Ethiopian highlands. A field experiment was conducted at Adet and Debre Tabor, three frequencies of fungicide (propiconazole, Tilt 250 EC) plus check and three varieties (Alidoro, Danda'a and Gambo) were used. The experiment was laid out in a randomized complete block design (RCBD) in factorial arrangement with three replications. SLB disease development was quite high at Debre Tabor compared to Adet. At Debre Tabor, the maximum SLB severity (78.8%) was noted on variety Gambo followed by Danda'a (70.3%) whereas 46.09% and 37.44% severities noted on these varieties at Adet, respectively. At Debre Tabor the highest sAUDPC (44.35%days and 39.8 %days), disease progress rate (0.019402 and 0.035895 unit/day) on all and flag leaves, respectively. The highest Septoria progress coefficient was noted from the unsprayed plot of Gambo (0.76). Based on the results, a single fungicide spray (Tilt 250EC) for Alidoro and Danda'a (moderately resistant and moderately susceptible) could minimize the epidemics of SLB. But for Gambo (susceptible variety) two fungicide spray reduces the progress and development of SLB. Timely application of efficient systemic fungicides could reduce the epidemics of the pathogen. However, other cultural methods could be further study for the epidemics of this particular pathogen.

**Contribution/Originality:** This study is one of very few studies which have investigated the combined effect of varieties with fungicide spray frequencies on Septoria leaf blotch epidemics that will have a positive contribution for economic fungicide spray and as integrated Septoria leaf blotch disease management.

### 1. INTRODUCTION

Bread wheat (*Triticum aestivum*) is one of the most important small grain cereals produced worldwide (Ayele *et al.*, 2008). It is estimated that more than 75% of the world's population consumes wheat as part of their daily diet. Currently, it is also becoming most important cereals grown on a large scale in the tropical and subtropical regions of the world (Gibson and Benson, 2002). Ethiopia is Africa's second largest wheat producer after South Africa and

the largest producer in Sub-Saharan Africa (ATA (Agricultural Transformation Agency), 2015). Wheat is mainly grown in the highlands of Ethiopia, which lie between 6 and 16°N and 35 and 42°E, at altitudes ranging from 1500 to 2800 masl and with mean minimum temperatures of 6°C to 11°C (Gashaw *et al.*, 2018).

In spite of the enormous economic significance of the crop in the country, its production and productivity are limited by various biotic and abiotic environmental factors (Hailu, 1991; Abera, 2017). Biotic stresses include diseases, insects and weeds (Ayele *et al.*, 2015; Abera, 2017) and abiotic constraints include drought, acidity, alkalinity, extreme temperature, depleted soil fertility and low adoption of new technologies. Of the biotic stress, Septoria leaf blotch (SLB) (*Mycosphaerella graminicola*, anamorph, *Septoria tritici*) (Allioui *et al.*, 2016) is currently one of the most important pathogens of bread wheat (*Triticum aestivum* L.) and durum wheat (*Triticum turgidum* L. subsp. durum) in many parts of the world (Boukef *et al.*, 2012). *M. graminicola* was rated as one of the top10 economically important fungal pathogens in the world (Dean *et al.*, 2012) and the most important disease in Ethiopia (Hulluka *et al.*, 1991). SLB poses a serious and persistent challenge to wheat grown in temperate climates throughout the world. Diseases caused by *Septoria spp.* are economically important in all wheat producing areas of the world (Hershman, 2012) and it causes yield losses from 30% to more than 70% (Eyal *et al.*, 1987). It is also become very severe in all released bread wheat cultivars and reaches the yield loss up to 82% in Ethiopia (KARC, 2005). At Holeta Agricultural Research Center, West Shewa, Ethiopia 41% yield losses of bread wheat have been recorded due to this disease (Abebe *et al.*, 2015). A survey conducted in northwestern Ethiopia reported stripe rust and septoria leaf blotch were the major diseases of wheat fields (AARC (Adet Agricultural Research Center), 2000). Another survey conducted in 2012 in western Amhara, including South Gondar, East Gojjam, Awi and West Gojjam, septoria leaf blotch was the most aggressive disease in all assessed bread wheat fields (Walleign *et al.*, 2014). Fungicide applications and the deployment of resistant wheat cultivars are among the most practices aiming to alleviate SLB (Lehoczki-Krsjak *et al.*, 2010). Planting of varieties with good levels of resistance will limit yield losses. Fungicides, including triadimefon, triadimenol, tebuconazole, propiconazole, and epoxiconazole are effective against of this pathogen (Grant, 2014). Fungicide application is effective to control SLB and their benefits have been long acknowledged, but they are not always timely applied and environmentally sound (Paveley *et al.*, 1997). It has been reported that sprays applied during the period from flag leaf to ear emergence had shown effective control of septoria (Cook *et al.*, 1999). Combined use of resistant varieties and fungicides is the best way to manage SLB disease in wheat (Andrew *et al.*, 2014). The use of relatively resistant cultivars or fungicide application at appropriate time and rate has a pronounced positive effect on the management of the disease of SLB (Ayele *et al.*, 2008). So far, there are some fungicides against SLB but still, there is inadequate information on economic fungicide spray frequencies with different varieties having different reaction level with SLB for the management of this disease in the western Amhara. Therefore the objective of this experiment was to determine the effects of varieties and fungicide spray frequencies on septoria leaf blotch disease epidemics on bread wheat.

## 2. MATERIALS AND METHODS

### 2.1. Description of the Study Area

The field experiment was conducted at Adet Agricultural Research Center and Debre-Tabor Research Sub Center during the main rainy seasons of 2017/2018. Adet is located 11°17' N latitude, at 37°43'E and the elevation is 2240 m.a.s.l and Debre-Tabor at 11°88'N latitude and 37°98' E longitude and elevation 2591masl.

### 2.2. Experimental Materials, Design and Procedures

Three bread wheat varieties having different level of reaction with septoria leaf blotch, moderately resistant (Alidoro), moderately susceptible (Danda'a), and susceptible (Gambo) that are relatively resistant to other diseases like wheat rusts (Temesgen *et al.*, 2000; Abebe *et al.*, 2015) were used. Four frequencies (0, 1x, 2x and 3x) of Propiconazole (Tilt 250 EC) at 0.5l/ha applications were used. The plot size was 6m<sup>2</sup> (2m width and 3m length).

Each plot has consisted of 10 rows and six harvestable central rows (3.6m<sup>2</sup>). The space between rows, plots and replications were 0.2m, 1 m and 2m wide, respectively. The fungicide was sprayed using hand sprayer. The experiment was laid down in Randomized Complete Block Design (RCBD) in factorial arrangement with three replications at two sites. The fungicide was sprayed in a 10 days interval. The base for the 10 days interval is due to the disease relatively long latent period (14-21 days) of SLB (Eyal *et al.*, 1987; Shaw, 1990). The fungicide sprays was started after booting- flag leaves visible because this is the most important spray as yield responses to flag leaf sprays are consistently profitable which contribute approximately 65% of yield (AHDB, 2016). During fungicide sprays, plastic sheets were used to separate the plot being sprayed from the adjacent plots and to prevent inter-plot interference due to spray drift. This was achieved by covering the adjacent plots using plastic sheet.

### 2.3. Data Collection

*Disease severity:* SLB severity was assessed on 10 randomly pre-tagged plants of the middle rows per plot on weekly interval from the time of disease appearance on the susceptible check until the crop attained its physiological maturity. The severity for flag leaf was taken independently. The average severity of 10 plants per plot was used for analysis. SLB severity was scored visually using a double-digit (00 to 99), modified version of Saari and Prescott's scale (Saari and Prescott, 1975; Eyal *et al.*, 1987) for wheat foliar diseases. The first digit (*D1*) indicates disease progress in plant height and the second digit (*D2*) refers to severity measured as the diseased leaf area. For each score, a percentage of disease severity was estimated based on the following formula.

$$\text{Severity} = \left( \frac{D1}{9} \times \frac{D2}{9} \right) * 100$$

#### 2.3.1. Septoria Progress Coefficient (SPC)

SPC was calculated by using the following formula  $\text{SPC} = \text{Disease height (cm)}/\text{Plant height (cm)}$ . Disease height is the maximum height (cm) from the ground where pycnidia of the pathogen are found on the plant and the plant height. The coefficient indicates the position of pycnidia relative to plant height regardless of pycnidial coverage (Eyal *et al.*, 1987). SPC is thus a ratio indicating the height reached by the disease. SPC of 0.0 would mean no disease at all, while SPC of 1.0 would indicate that the disease is covering the entire plant.

#### 2.3.2. The Area under Disease Progress Curve (AUDPC)

AUDPC values were calculated for each plot using the following formula and the value was expressed in %-days (Wilcoxson *et al.*, 1975; Campbell and Madden, 1990) and standardized by dividing the value by the total number of days within the range of scoring dates.

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

Where,  $X_i$  is the cumulative disease severity expressed as a proportion at the  $i$ th observation;  $t_i$  is the time (days after planting) at the  $i$ th observation and  $n$  is total number of observations.

#### 2.3.3. Disease Progress Rate ('r')

Disease progress rate: Logistic,  $\ln \left[ \frac{Y}{1-Y} \right]$  (Plank, 1963) and Gompertz,  $-\ln[-\ln(Y)]$  (Berger, 1981) models was compared for estimation of disease progression parameters from each treatment. The transformed data was regressed over time (DAP) to determine the model. The goodness of fit of the models was tested based on the magnitude of the coefficient of determination ( $R^2$ ) and residuals (SE) were obtained using each model (Campbell and Madden, 1990). Then the appropriate model was used to determine the apparent rate ( $r$ ) of disease increase.

The disease infection rate was used in the analysis of variance (ANOVA) to compare the disease progress among the treatments.

#### 2.4. Data Analysis

All the collected data were subjected to analysis of variance (ANOVA) by using the methods described by Gomez and Gomez (1984) using SAS computer software 9.0. Measured parameters were subjected logarithmic transformation before analysis to normalize the data analysis. Least Significant Difference (LSD) values were used to separate differences among treatment means.

### 3. RESULT AND DISCUSSION

#### 3.1. Septoria Leaf Blotch Severity on All Leaves

At Debre Tabor on all leaves of Alidoro assessments made on 46 (32 Zadock Growth Stage, ZGS), 53 (33 ZGS), and 60 (35 ZGS) 67 (53 ZGS), 74 (57 ZGS) and 81 (61 ZGS) DAP there was no statistically significant difference among fungicide spray frequencies (unsprayed, 1x, 2x, and 3x times) within the assessment dates. Insignificant variation among sprayed plots with in variety at early assessment dates might be due to the low movement of fungicide to the plant tissue. Similarly, propiconazole has a nature of steady movement of in crop tissue system (Buchenauer, 1987; Kebede, 2006). However, SLB assessment made on 88 DAP (63 ZGS), 96 DAP (71 ZGS) and 103 DAP (73 ZGS) only unsprayed plots showed significant differences with high severity level from others treatments, as they remain non-significantly different each other. At the final severity assessment date 109 DAP (75 ZGS) non-significant difference was observed between three and two time's application but significantly different between three times application with unsprayed and one times application Table 1. At Debre Tabor All leaves of Danda'a SLB severity assessment made on 46 (29 ZGS), 53 (31 ZGS), and 60 (33 ZGS), there was no statistically significant difference among fungicide spray frequencies. However, starting from 67 DAP (47 ZGS), there was a significance difference on severity, unsprayed plots with other respective plots. At the final assessment date 109 DAP (73GS) the highest disease severity was recorded on the unsprayed plots 70.28%, and 45.88%, 31.68% and 31.27% on 1x, 2x, and 3x times fungicide sprayed plots Table 1. On Gambo, susceptible variety the disease was more severe than other varieties. On the first three assessment dates the disease there was no significant difference among fungicide spray frequencies, but after the fourth assessment there was a significant difference on fungicide spray. At the fourth assessment date 67 DAP (57 ZGS) the highest disease severity was recorded on the unsprayed plots 39.09% followed by one times spray 29.42%. On the fifth assessment date the unsprayed plot was significant difference among the other fungicide spray frequencies. The disease development was very high on this variety up to the final assessment dates with the highest severity value. On all leaves of Gambo, SLB developed alarmingly compared with Alidoro and Danda'a at both locations Table 1. It confirmed the idea of Eyal *et al.* (1987) that on natural epidemics, latent period and the rate of disease development are affected by resistant level of the crop. At Adet SLB was first appeared very late as compared to the disease appearance at Debre Tabor with low level of intensity. At this location, on the variety Alidoro on all leaves no disease were appeared on the initial assessment and the pathogen started infection on unsprayed and 1 times sprayed plots with very low severity level at the second assessment date 72 DAP. But at the terminal scoring date (100 DAP) the unsprayed plots found to be more infected to the disease (28.80%) and low severity was scored on three times fungicide sprayed plots (7.01%) but no difference was found on two and one times sprayed plots Table 2. The level of disease severity at Adet on the two varieties *i.e.* Danda'a and Gambo which are moderately susceptible and susceptible respectively, the severity was consistent with fungicide spray frequencies which implies the highest severity recorded on the unsprayed plots on both varieties while the lowest recorded on the three times sprayed plot with the maximum severity (46.09%) on Gambo and (37.44%) Danda'a unsprayed plots at the last assessment date 100 DAP (81 ZGS) Table 2 SLB severity assessments were made up to 100 DAP at Adet then stopped because of leaves senses. This hastened premature

leaves senses was one of the negative impact of SLB (Magboul *et al.*, 1992) and moisture stress due to low/no rain fall at the later growth stage of the crop.

**Table-1.** Effect of three bread wheat varieties and different foliar fungicide application frequency on the severity of SLB on all leaves at Debre- Tabor during 2017 cropping season.

| Variety        | FAF       | SLB severity (%) at different DAP |       |       |                    |                     |                     |                     |                      |                      |                     |
|----------------|-----------|-----------------------------------|-------|-------|--------------------|---------------------|---------------------|---------------------|----------------------|----------------------|---------------------|
|                |           | 46DAP                             | 53DAP | 60DAP | 67DAP              | 74DAP               | 81DAP               | 88DAP               | 95DAP                | 102DAP               | 109DAP              |
| <i>Alidoro</i> | Unsprayed | 0.00                              | 1.23  | 2.00  | 6.58 <sup>ef</sup> | 10.12 <sup>de</sup> | 13.57 <sup>de</sup> | 23.04 <sup>e</sup>  | 26.50 <sup>de</sup>  | 33.13 <sup>ef</sup>  | 36.83 <sup>e</sup>  |
|                | 1times    | 0.00                              | 0.41  | 2.46  | 3.37 <sup>f</sup>  | 5.92 <sup>e</sup>   | 9.83 <sup>de</sup>  | 12.59 <sup>f</sup>  | 16.05 <sup>f</sup>   | 23.45 <sup>gh</sup>  | 30.86 <sup>ef</sup> |
|                | 2times    | 0.00                              | 1.23  | 2.28  | 4.11 <sup>f</sup>  | 5.76 <sup>e</sup>   | 8.64 <sup>e</sup>   | 11.72 <sup>f</sup>  | 14.81 <sup>f</sup>   | 20.57 <sup>gh</sup>  | 28.6 <sup>fg</sup>  |
|                | 3times    | 0.00                              | 0.82  | 1.64  | 3.29 <sup>f</sup>  | 5.18 <sup>e</sup>   | 7.94 <sup>e</sup>   | 11.23 <sup>f</sup>  | 14.61 <sup>f</sup>   | 16.79 <sup>h</sup>   | 22.01 <sup>g</sup>  |
| <i>Danda'a</i> | Unsprayed | 2.46                              | 3.70  | 6.58  | 16.20 <sup>d</sup> | 25.10 <sup>c</sup>  | 39.42 <sup>bc</sup> | 48.97 <sup>c</sup>  | 57.61 <sup>b</sup>   | 66.25 <sup>b</sup>   | 70.28 <sup>b</sup>  |
|                | 1times    | 2.45                              | 4.11  | 7.41  | 10.78 <sup>e</sup> | 15.22 <sup>d</sup>  | 16.87 <sup>d</sup>  | 21.32 <sup>e</sup>  | 32.92 <sup>d</sup>   | 40.33 <sup>de</sup>  | 45.88 <sup>d</sup>  |
|                | 2times    | 2.88                              | 3.29  | 4.94  | 10.70 <sup>e</sup> | 14.32 <sup>d</sup>  | 15.10 <sup>de</sup> | 19.34 <sup>ef</sup> | 23.08 <sup>def</sup> | 26.95 <sup>fg</sup>  | 31.68 <sup>ef</sup> |
|                | 3times    | 2.05                              | 4.11  | 5.51  | 9.80 <sup>e</sup>  | 11.10 <sup>de</sup> | 13.90 <sup>de</sup> | 18.84 <sup>ef</sup> | 22.84 <sup>ef</sup>  | 25.02 <sup>fgh</sup> | 31.27 <sup>ef</sup> |
| <i>Gambo</i>   | Unsprayed | 3.70                              | 11.11 | 16.04 | 39.09 <sup>a</sup> | 48.88 <sup>a</sup>  | 60.20 <sup>a</sup>  | 72.30 <sup>a</sup>  | 75.47 <sup>a</sup>   | 77.78 <sup>a</sup>   | 77.78 <sup>a</sup>  |
|                | 1times    | 4.52                              | 9.87  | 13.57 | 29.42 <sup>b</sup> | 39.50 <sup>b</sup>  | 46.09 <sup>b</sup>  | 60.49 <sup>b</sup>  | 67.69 <sup>a</sup>   | 71.44 <sup>ab</sup>  | 73.46 <sup>ab</sup> |
|                | 2times    | 3.70                              | 11.00 | 13.16 | 28.80 <sup>b</sup> | 39.09 <sup>b</sup>  | 43.62 <sup>b</sup>  | 46.09 <sup>c</sup>  | 49.21 <sup>c</sup>   | 53.57 <sup>c</sup>   | 58.19 <sup>c</sup>  |
|                | 3times    | 2.87                              | 8.64  | 13.57 | 21.39 <sup>c</sup> | 27.77 <sup>c</sup>  | 31.89 <sup>c</sup>  | 37.16 <sup>d</sup>  | 44.69 <sup>c</sup>   | 46.5 <sup>cd</sup>   | 48.68 <sup>d</sup>  |
| Cv (%)         |           | 43.1                              | 23.6  | 22.6  | 19.8               | 18.2                | 17.8                | 15.2                | 16                   | 13.5                 | 9.9                 |
| Sig.difference |           | ns                                | ns    | ns    | *                  | *                   | **                  | **                  | *                    | *                    | *                   |

**Remark:** SLB=Septoria leaf blotch; FAF=Fungicide application frequency; DAP=Days after planting; CV=Coefficient of variation; LSD=Least significant difference. \*=significant difference at p<0.05, \*\*=significant differences at p<0.01; ns=non-significant difference; Means with the same letter are not significantly different.

**Table-2.** Effect of three bread wheat varieties and different foliar fungicide spray frequency on the severity of SLB on all leaves at Adet during 2017 cropping season.

| Variety        | FAF       | SLB severity (%) at different DAP |                    |                    |                    |                      |                      |
|----------------|-----------|-----------------------------------|--------------------|--------------------|--------------------|----------------------|----------------------|
|                |           | 65DAP                             | 72DAP              | 79DAP              | 86DAP              | 93DAP                | 100DAP               |
| Alidoro        | Unsprayed | 0.00 <sup>d</sup>                 | 0.21 <sup>d</sup>  | 1.39 <sup>de</sup> | 6.57 <sup>cd</sup> | 20.57 <sup>bc</sup>  | 28.80 <sup>bc</sup>  |
|                | 1times    | 0.00 <sup>d</sup>                 | 0.20 <sup>d</sup>  | 1.44 <sup>de</sup> | 3.08 <sup>d</sup>  | 11.93 <sup>cde</sup> | 17.28 <sup>efg</sup> |
|                | 2times    | 0.00 <sup>d</sup>                 | 0.00 <sup>d</sup>  | 0.00 <sup>e</sup>  | 3.20 <sup>d</sup>  | 5.34 <sup>de</sup>   | 10.70 <sup>fg</sup>  |
|                | 3times    | 0.00 <sup>d</sup>                 | 0.00 <sup>d</sup>  | 0.41 <sup>e</sup>  | 3.00 <sup>d</sup>  | 4.52 <sup>e</sup>    | 7.01 <sup>g</sup>    |
| Danda'a        | Unsprayed | 1.02 <sup>c</sup>                 | 1.43 <sup>c</sup>  | 5.76 <sup>b</sup>  | 10.70 <sup>b</sup> | 26.75 <sup>ab</sup>  | 37.44 <sup>ab</sup>  |
|                | 1times    | 0.00 <sup>d</sup>                 | 0.00 <sup>d</sup>  | 0.00 <sup>e</sup>  | 4.93 <sup>cd</sup> | 14.40 <sup>cd</sup>  | 22.63 <sup>cd</sup>  |
|                | 2times    | 0.00 <sup>d</sup>                 | 1.23 <sup>c</sup>  | 2.75 <sup>c</sup>  | 3.29 <sup>d</sup>  | 12.35 <sup>cde</sup> | 18.52 <sup>def</sup> |
|                | 3times    | 0.00 <sup>d</sup>                 | 0.00 <sup>d</sup>  | 0.00 <sup>e</sup>  | 2.87 <sup>d</sup>  | 7.41 <sup>de</sup>   | 11.52 <sup>efg</sup> |
| Gambo          | Unsprayed | 2.44 <sup>a</sup>                 | 4.94 <sup>a</sup>  | 9.05 <sup>a</sup>  | 15.22 <sup>a</sup> | 33.33 <sup>a</sup>   | 46.09 <sup>a</sup>   |
|                | 1times    | 1.23 <sup>c</sup>                 | 2.05 <sup>b</sup>  | 5.76 <sup>b</sup>  | 8.23 <sup>b</sup>  | 14.41 <sup>cd</sup>  | 28.80 <sup>bc</sup>  |
|                | 2times    | 1.56 <sup>b</sup>                 | 1.72 <sup>bc</sup> | 4.11 <sup>c</sup>  | 6.42 <sup>cd</sup> | 11.11 <sup>cde</sup> | 20.57 <sup>cde</sup> |
|                | 3times    | 0.00 <sup>d</sup>                 | 0.00 <sup>d</sup>  | 1.23 <sup>de</sup> | 5.14 <sup>cd</sup> | 8.22 <sup>de</sup>   | 18.52 <sup>def</sup> |
| Cv (%)         |           | 27.1                              | 33.3               | 36.2               | 40.1               | 36.1                 | 21.8                 |
| Sig.difference |           | **                                | **                 | **                 | Ns                 | ns                   | Ns                   |

Remark: SLB=Septoria leaf blotch; FAF=Fungicide application frequency; DAP=Days after planting; CV=Coefficient of variation; LSD=Least significant difference. \*=significant difference at  $p<0.05$ , \*\*=significant differences at  $p<0.01$ ; ns=non-significant difference; Means with the same letter are not significantly different.

### 3.2. Septoria Leaf Blotch Severity on Flag Leaves

At Debre Tabor, symptom of SLB first observed on flag leaf of susceptible variety Gambo on 81 DAP at crop growth stage ZGS 60 with severity level of 9.33%, 4.00%, 2.67% and 0.33%, on unsprayed, 1x, 2x, and 3x times fungicide sprayed plots respectively and, on the variety, Danda'a on unsprayed plots with severity level 2.60% Table 4. On flag leaf of Gambo, on unsprayed plot SLB began with high severity level (9.33%) and it reached its maximum (72%) on 109 DAP severities Table 4. The analysis of variance on the variety Alidoro at Debre Tabor showed that non-significant on the first three consecutive assessment dates 81 DAP, 88 DAP and 95 DAP. However, on 88 DAP the highest severity was recorded on the unsprayed plots with severity level 1.33%. At the terminal scoring date there was significant difference ( $P<0.05$ ) among fungicide spray frequency with the highest severity recorded on the unsprayed plots 33.33% and the lowest severity three times application 9.33% Table 4. On the moderately susceptible variety Danda'a at the initial assessment date 81 DAP there was significant difference ( $P<0.01$ ) between unsprayed plots with other fungicide spray frequencies. At 88 DAP on flag leaf of Danda'a two and three times sprayed plots even though SLB began with relatively high severity level (0.33%) and (0.67%) than one times sprayed plot (0.00%), it exceeded after third assessment date (96 DAP) and it reached its maximum severity 63.33%, 43.33%, 14.67% and 10.00% on unsprayed, one, two, and three times sprayed plots respectively at the final assessment date 109 DAP (73 ZGS) Table 4. It indicates the disease could not be controlled by a single application. Similarly, Eyal *et al.* (1987) reported that several foliar sprays are required to control septoria leaf blotch but Cook concluded that a single well-timed spray was adequate. The result of this study is in contrast with Brown (1984) one foliar spray about 2 months after sowing controlled the disease for most of the growing season. It is in agreement with disease development rate is affected by the resistant level of the crop and it is high on susceptible and low on resistant ones. Similarly, Loughman and Thomas (1991) found that three sprays of Tilt were more effective at reducing disease than single sprays but did not increase yield beyond that obtained with single late spray.

At Adet similar trends were happened as like Debre Tabor. In this study, different epidemic levels were achieved on the flag leaves by applying different fungicide frequencies Table 3 and Table 4. At both locations the highest severity was recorded on Gambo; which is susceptible to SLB, consistently for all fungicide spray frequencies (i.e. one, two, three times sprayed and unsprayed plots) compared with their respective severity levels on Danda'a and Alidoro on both all and flag leaves. The lowest severity was recorded from three time sprayed plot of Alidoro. However, their level of severity varies all varieties under the study were found to be susceptible

including Alidoro, previously reported as moderately resistant on other location. This share the idea of “often wheat cultivars reported as resistant in one region have been found to be susceptible in another due to the genetic composition of the local pathogen population, which can be affected by cultivars grown, the suitability of the environment for infection, and the relative importance of the sexual stage in the disease cycle. The idea is supported by Eyal *et al.* (1987) and Alemar (2013) that flag leaves have more time for infection than other leaves. Similarly, Arraiano and Brown (2006) reported that flag leaves expanded for a length of time tend to have larger amounts of disease.

**Table-3.** Effect of varieties and fungicide spray frequencies on SLB severity on flag leaves at Adet during 2017 cropping season.

| Variety        | FAF       | Adet                              |                       |                     |
|----------------|-----------|-----------------------------------|-----------------------|---------------------|
|                |           | SLB severity (%) at different DAP |                       |                     |
|                |           | 86DAP                             | 93DAP                 | 100DAP              |
| <i>Alidoro</i> | Unsprayed | 0.67 <sup>cd</sup>                | 5.30 <sup>bcd</sup>   | 10.33 <sup>bc</sup> |
|                | 1times    | 0.00 <sup>d</sup>                 | 2.33 <sup>efgh</sup>  | 5.60 <sup>de</sup>  |
|                | 2times    | 0.00 <sup>d</sup>                 | 0.67 <sup>gh</sup>    | 5.00 <sup>de</sup>  |
|                | 3times    | 0.00 <sup>d</sup>                 | 0.00 <sup>h</sup>     | 1.33 <sup>e</sup>   |
| <i>Danda'a</i> | Unsprayed | 2.30 <sup>b</sup>                 | 6.70 <sup>bc</sup>    | 14.00 <sup>b</sup>  |
|                | 1times    | 0.70 <sup>cd</sup>                | 3.70 <sup>def</sup>   | 7.66 <sup>cd</sup>  |
|                | 2times    | 0.33 <sup>d</sup>                 | 3.00 <sup>defg</sup>  | 6.70 <sup>cd</sup>  |
|                | 3times    | 0.00 <sup>d</sup>                 | 1.00 <sup>fgh</sup>   | 3.33 <sup>de</sup>  |
| <i>Gambo</i>   | Unsprayed | 4.67 <sup>a</sup>                 | 13.66 <sup>a</sup>    | 25.00 <sup>a</sup>  |
|                | 1times    | 1.73 <sup>bc</sup>                | 7.00 <sup>b</sup>     | 12.30 <sup>b</sup>  |
|                | 2times    | 2.00 <sup>b</sup>                 | 4.00 <sup>cde</sup>   | 11.00 <sup>bc</sup> |
|                | 3times    | 0.00 <sup>d</sup>                 | 2.66 <sup>defgh</sup> | 7.00 <sup>cd</sup>  |
| Sig.difference |           | **                                | ns                    | *                   |
| CV (%)         |           | 30.9                              | 41.5                  | 29.6                |

**Remark:** SLB=Septoria leaf blotch; FAF=Fungicide application frequency; DAP=Days after planting; CV=Coefficient of variation; LSD=Least significant difference. \*=significant difference at p<0.05, \*\*=significant differences at p<0.01; ns=non-significant difference; Means with the same letter are not significantly different.

**Table-4.** Interaction effect of three bread wheat varieties and foliar fungicide application frequency on SLB severity at different DAP on Flag leaves at Debre Tabor during 2017 cropping season.

| Variety        | FAF       | Debre Tabor                       |                           |                           |                            |                             |
|----------------|-----------|-----------------------------------|---------------------------|---------------------------|----------------------------|-----------------------------|
|                |           | SLB severity (%) at different DAP |                           |                           |                            |                             |
|                |           | 81DAP                             | 88DAP                     | 95DAP                     | 102DAP                     | 109DAP                      |
| <i>Alidoro</i> | Unsprayed | 0.00 (0.00) <sup>d</sup>          | 1.33 (0.30) <sup>de</sup> | 13.33 (1.41) <sup>d</sup> | 24.33 (1.40) <sup>cd</sup> | 33.33 (1.53) <sup>cde</sup> |
|                | 1times    | 0.00 (0.00) <sup>d</sup>          | 0.00 (0.00) <sup>e</sup>  | 6.66 (0.82) <sup>de</sup> | 16.00 (1.22) <sup>de</sup> | 21.67 (1.35) <sup>ef</sup>  |
|                | 2times    | 0.00 (0.00) <sup>d</sup>          | 0.00 (0.00) <sup>e</sup>  | 1.66 (0.26) <sup>e</sup>  | 6.33 (0.85) <sup>f</sup>   | 12.33 (1.11) <sup>fg</sup>  |
|                | 3times    | 0.00 (0.00) <sup>d</sup>          | 0.00 (0.00) <sup>e</sup>  | 0.33 (0.10) <sup>e</sup>  | 2.66 (0.46) <sup>f</sup>   | 9.33 (0.97) <sup>g</sup>    |
| <i>Danda'a</i> | Unsprayed | 2.60 (0.66) <sup>bc</sup>         | 6.00 (0.84) <sup>c</sup>  | 25.00 (1.41) <sup>c</sup> | 53.33 (1.73) <sup>b</sup>  | 63.33 (1.84) <sup>ab</sup>  |
|                | 1times    | 0.00 (0.00) <sup>d</sup>          | 0.0 (0.00) <sup>e</sup>   | 6.67 (0.86) <sup>de</sup> | 29.00 (1.46) <sup>c</sup>  | 43.33 (1.63) <sup>c</sup>   |
|                | 2times    | 0.00 (0.00) <sup>d</sup>          | 0.33 (0.10) <sup>e</sup>  | 3.00 (0.49) <sup>e</sup>  | 8.00 (0.90) <sup>ef</sup>  | 14.67 (1.19) <sup>fg</sup>  |
|                | 3times    | 0.00 (0.00) <sup>d</sup>          | 0.67 (0.16) <sup>de</sup> | 1.16 (0.16) <sup>de</sup> | 3.66 (0.62) <sup>f</sup>   | 10.00 (1.04) <sup>fg</sup>  |
| <i>Gambo</i>   | Unsprayed | 9.33 (1.01) <sup>a</sup>          | 26.66 (1.43) <sup>a</sup> | 55.00 (1.74) <sup>a</sup> | 70.00 (1.85) <sup>a</sup>  | 72.66 (1.88) <sup>a</sup>   |
|                | 1times    | 4.00 (0.68) <sup>b</sup>          | 9.33 (1.01) <sup>b</sup>  | 35.66 (1.55) <sup>b</sup> | 50.00 (1.70) <sup>b</sup>  | 59.00 (1.77) <sup>b</sup>   |
|                | 2times    | 2.67 (0.56) <sup>c</sup>          | 4.66 (0.75) <sup>c</sup>  | 12.66 (1.11) <sup>d</sup> | 29.66 (1.48) <sup>c</sup>  | 36.67 (1.57) <sup>cd</sup>  |
|                | 3times    | 0.33 (0.10) <sup>d</sup>          | 5.33 (0.77) <sup>c</sup>  | 13.33 (1.13) <sup>d</sup> | 23.33 (1.38) <sup>cd</sup> | 27.33 (1.45) <sup>cde</sup> |
| Sig.difference |           | **                                | *                         | ns                        | ns                         | *                           |
| CV (%)         |           | 31.5                              | 32.6                      | 25.7                      | 14.0                       | 6.2                         |

**Remark:** SLB=Septoria leaf blotch; FAF=Fungicide application frequency; DAP=Days after planting; CV=Coefficient of variation; LSD=Least significant difference. \*=significant difference at p<0.05, \*\*=significant differences at p<0.01; ns=non-significant difference; Means with the same letter are not significantly different (Values in parenthesis are log transformed values)

### 3.3. Area under Disease Progress Curve (AUDPC)

The Area under Disease Progress Curve (AUDPC) values on all and flag leaves at both locations were standardized by dividing it with its total number of days between the first and last assessment dates.



The highest sAUDPC values were recorded on unsprayed (control) plots of Gambo 44.35%days, Danda'a 30.14%days and Alidoro 13.46%days on all leaves of each variety Figure 1. On flag leaves at Debre Tabor follows the same pattern that of all leaves Figure 1. The highest sAUDPC values was recorded on unsprayed plots of variety Gambo, Danda'a and Alidoro, 39.8, 23.8 and 11.13 %days respectively Figure 1. At Debre Tabor, on all leaves of Alidoro, AUDPC value on unsprayed plot showed significant difference from all its sprayed plots. But, 1x, 2x, and 3x times fungicide sprayed treatments were not significantly differed. On the variety Danda'a (moderately susceptible) on all leaves there was no significant difference between 2x 3x fungicide spray but significant difference between unsprayed and 1x fungicide spray for this variety Figure 1. On the variety Gambo on both all and flag leaves there were significant difference on the sAUDPC except that there was no significant difference ( $P>0.05$ ) on two and three times spray on flag leaves. The lowest sAUDPC was calculated from the three times fungicide sprayed treatments on both flag and all leaves with values 11.2 and 25.8%days respectively.

At Adet, the highest sAUDPC (19.3 %days) was recorded on Gambo and the lowest was calculated (1.9%days) from three times sprayed plots of Alidoro. Unsprayed plots of Alidoro were significantly different among one, two and three times fungicide sprayed plots. Similarly, in the moderately susceptible variety (Danda'a) the value for sAUDPC calculated from the unsprayed plots were significantly different from other sprayed plots Figure 2. Generally, sAUDPC was high in Gambo, followed by Danda'a and the lowest was calculated from the Alidoro which is moderately resistant variety on both all and flag leaves Figure 2. This proved that high level of septoria leaf blotch was developed on the susceptible variety (Gambo) and low on the moderately resistant variety (Alidoro). Similarly, Ghaffary *et al.* (2011) indicated that varieties differ greatly in their reaction to infection.

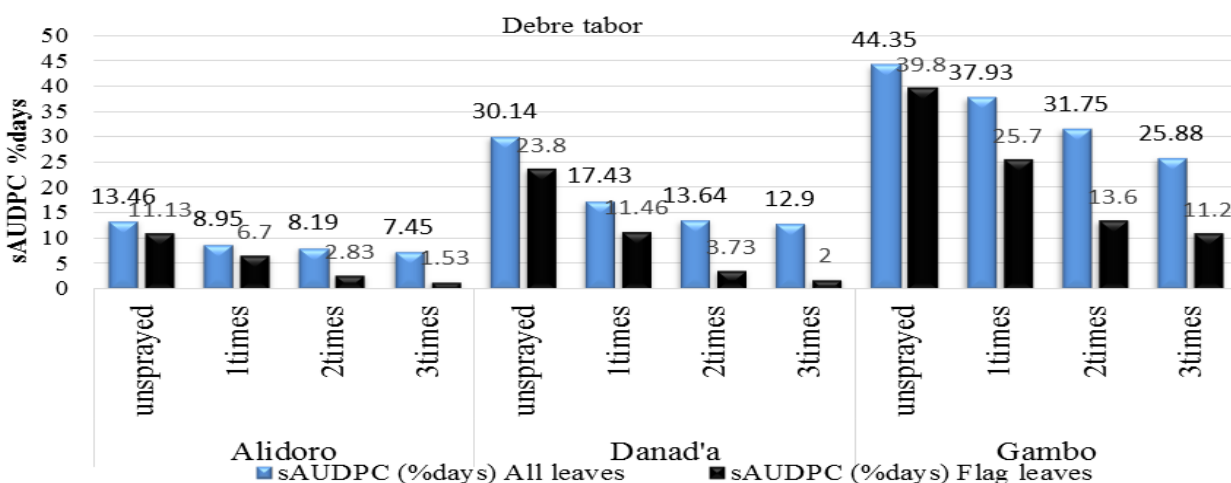


Figure-1. Standardized area under disease progress curve (sAUDPC) in all and flag leaves at Debre Tabor during 2017 cropping season. sAUDPC: standardized area under disease progress curve.

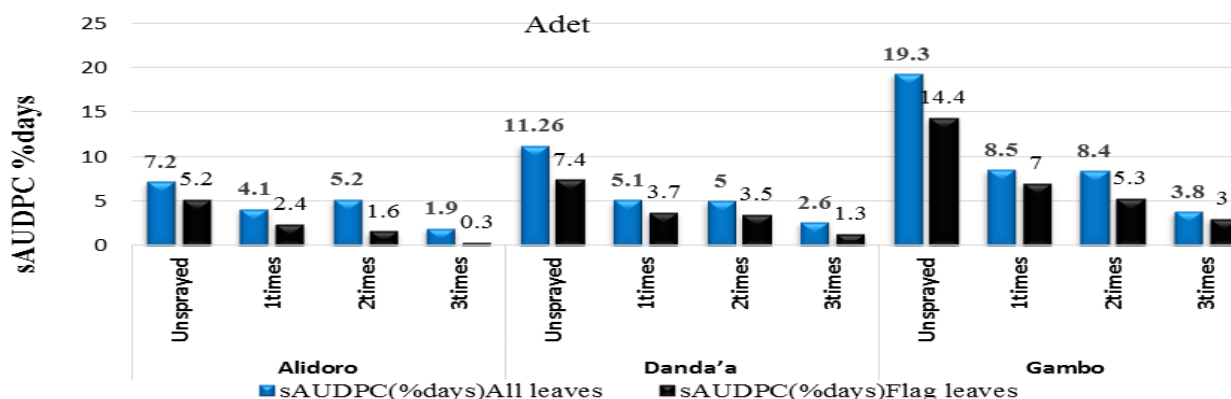


Figure-2. Standardized area under disease progress curve (sAUDPC) in all and flag leaves at Adet during 2017 cropping season. Remark: sAUDPC: standardized area under disease progress curve

### 3.4. Disease Progress Curve and Rate

Septoria leaf blotch was progressed linearly for each variety from the first disease assessment to physiological maturity/last assessment. At Debre Tabor on all leaves of the variety Gambo (susceptible variety) the severity was reached above 40% with few days after the occurrence of the disease. At the final assessment date, the disease severity reached about 78.78%. The progress of the disease was lower on Alidoro varieties followed by Danda'a [Figure 3](#). This could verify varieties are greatly differing for their infection to septoria leaf blotch. At Debre Tabor on all varieties, development of Septoria severity showed continuous increasing [Figure 4](#).

Disease progress curve showed typical sigmoid shape on all leaves of unsprayed plots of Gambo, Danda'a and Alidoro [Figure 3](#). It is typical characteristics of polycyclic disease. Again, septoria development on flag leaf of unsprayed plot of the three varieties showed the same sigmoid shape [Figure 4](#). But it was affected by resistant level of the varieties in which the lowest progress occurred on Alidoro which is moderately resistant to Septoria leaf blotch. The increase in rainfall and relative humidity contributed to the linear increment of the disease. The impacts of environmental factors, including temperature, relative humidity and rainfall, on the occurrence of septoria leaf blotch were very obvious. Disease intensity correlated, positively with relative humidity and rainfall. Similarly, [Hess and Shaner \(1985\)](#) reported that disease severity on the flag leaves increased as the moist period increases. It is also in line with, [Magboul et al. \(1992\)](#) had showed that there was a linear relationship between leaf wetness period and the rate of disease development. At Debre Tabor on all leaves the highest disease progress rate was obtained from on the unsprayed plots of Gambo (0.019402 unit per day) followed by unsprayed plots of Danda'a (0.017433 unit per day). The lowest progress rate was recorded from three time's spray of Danda'a and 3 times spray of Alidoro variety with value of 0.0074499 and 0.007929 respectively. Similar trends also happen in disease progress rate on flag leaves with the highest rate on the unsprayed plots of susceptible variety (Gambo)  $r=0.035895$  units per day followed by unsprayed plots of Danda'a  $r=0.035113$  units per day. The minimum progress rate per day was recorded on the moderately resistant variety (Alidoro). On this variety on three times sprayed plots the progress rate was low  $r=0.01029$  units/day. On the three varieties the trend of disease progress rate shows decreasing from the control plot to three times spray [Table 5](#).

At Adet on all leaves the highest disease progress rate was occurred on the moderately susceptible variety (Danda'a) on 1 times fungicide spray even though there is no significant difference with unsprayed plots. The disease progress rate on all leaves of Alidoro was  $r= 0.0979, 0.0966, 0.0812$  and  $0.0703$  on unsprayed, 1x, 2x and 3x times application respectively. On the variety Danda'a the disease progress was a bit fast as compared to other varieties with the values  $r=0.1051, 0.1102, 0.0869,$  and  $0.0935$  on unsprayed, 1times, 2 times and 3times fungicide spray. The highest disease progress rate was calculated for unsprayed plots of Gambo 0.023402 and the lowest for three sprayed plots of moderately resistant variety Alidoro 0.005637 unit/day [Table 5](#). In general progress rate was high on variety Gambo and the lowest rate was calculated for Alidoro, on which it is moderately resistant followed by Danda'a; which is moderately susceptible at Debre Tabor. But at Adet on all leaves the progress rate was fast on Danda'a this might be variety may be losing its resistance. Similarly, [Ayele et al. \(2008\)](#) reported that unlike other disease, a satisfactory result on resistance was not found to SLB in Ethiopia. It also agreed with [Temesgen et al. \(2000\)](#) indicted that disease development rate is affected by the resistant level of the crop and it is high on susceptible and low on resistant ones.

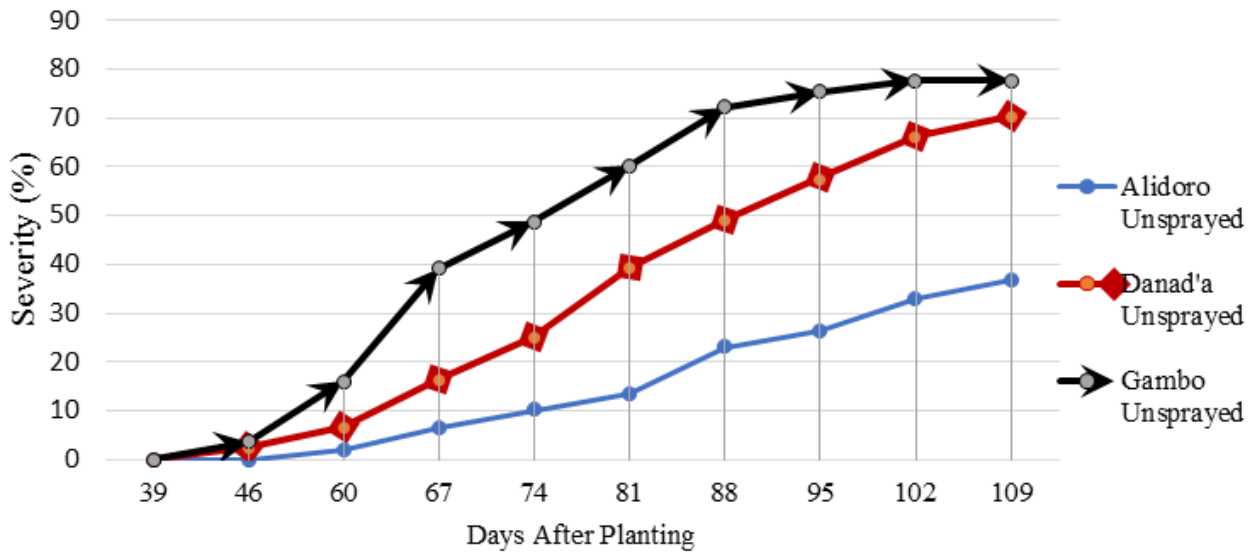


Figure-3. Septoria leaf blotch progress curve under natural infestation on three bread wheat varieties on all leaves, at Debre Tabor during 2017cropping season.

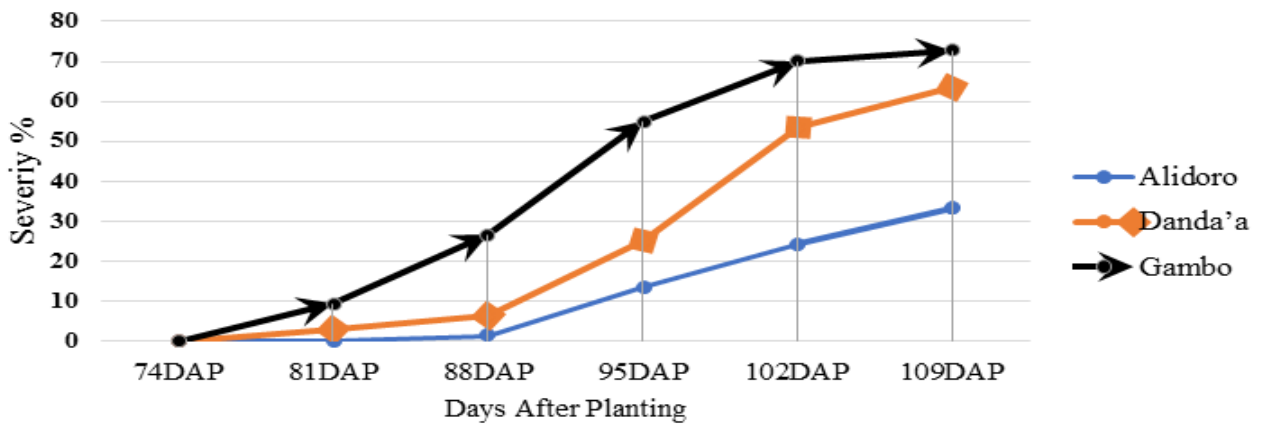


Figure-4. Septoria leaf blotch progress curve under natural infestation on three bread wheat varieties on flag leaves, at Debre Tabor during 2017cropping season.

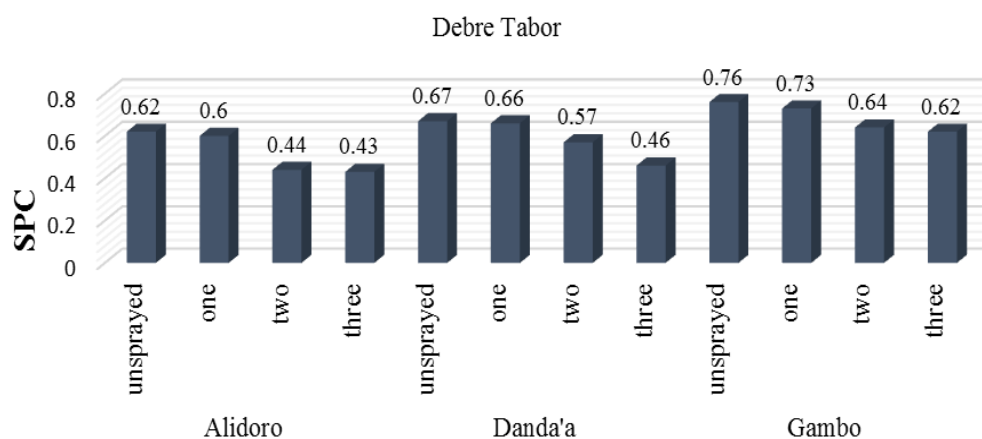
Table-5. SLB progress rates on all and flag leaves of three bread wheat varieties under different fungicide spray frequencies at Debre Tabor and Adet during 2017 cropping season.

| Disease progress rate (unit/day) |           |                         |                         |                         |             |
|----------------------------------|-----------|-------------------------|-------------------------|-------------------------|-------------|
| Treatments                       |           | Debre Tabor             |                         | Adet                    |             |
| Variety                          | FAF       | All leaves              | Flag leaves             | All leaves              | Flag leaves |
| Alidoro                          | Unsprayed | 0.011241 <sup>b</sup>   | 0.024548 <sup>bc</sup>  | 0.097923 <sup>ab</sup>  | 0.020372    |
|                                  | 1times    | 0.009432 <sup>bcd</sup> | 0.019939 <sup>cde</sup> | 0.096636 <sup>bcd</sup> | 0.016402    |
|                                  | 2times    | 0.008322 <sup>cde</sup> | 0.013692 <sup>ef</sup>  | 0.081211 <sup>de</sup>  | 0.016452    |
|                                  | 3times    | 0.007929 <sup>de</sup>  | 0.010291 <sup>f</sup>   | 0.070389 <sup>ef</sup>  | 0.005637    |
| Danda'a                          | Unsprayed | 0.017433 <sup>a</sup>   | 0.035113 <sup>a</sup>   | 0.105186 <sup>ab</sup>  | 0.017737    |
|                                  | 1times    | 0.010330 <sup>bcd</sup> | 0.029868 <sup>ab</sup>  | 0.110228 <sup>a</sup>   | 0.015193    |
|                                  | 2times    | 0.007701 <sup>de</sup>  | 0.014819 <sup>def</sup> | 0.086945 <sup>cde</sup> | 0.017863    |
|                                  | 3times    | 0.007449 <sup>e</sup>   | 0.010937 <sup>f</sup>   | 0.086539 <sup>cde</sup> | 0.010191    |
| Gambo                            | Unsprayed | 0.019402 <sup>a</sup>   | 0.035895 <sup>a</sup>   | 0.093553 <sup>bcd</sup> | 0.023420    |
|                                  | 1times    | 0.017042 <sup>a</sup>   | 0.030093 <sup>ab</sup>  | 0.081362 <sup>de</sup>  | 0.017689    |
|                                  | 2times    | 0.01185 <sup>b</sup>    | 0.020665 <sup>cd</sup>  | 0.061222 <sup>f</sup>   | 0.015419    |
|                                  | 3times    | 0.010504 <sup>bc</sup>  | 0.020661 <sup>cd</sup>  | 0.074797 <sup>ef</sup>  | 0.017796    |
| CV%                              |           | 13.6                    | 17.6                    | 11.2                    | 30.2        |
| Sig.difference                   |           | **                      | **                      | **                      | ns          |

Remark: CV=Coefficient of variation; \*=significant difference at p<0.05, \*\*=significant differences at p<0.01; ns=non-significant difference; Means with the same letter are not significantly different

### 3.5. Septoria Progress Coefficient (SPC)

At Debre Tabor on the unsprayed plots of Gambo (susceptible variety) the SPC was very high (0.76) followed by one times application (0.73) of this variety. This indicates all flag leaves were affected by the disease. Three times fungicide spray in Gambo was 0.62 and 0.64 on the two times fungicide spray. In the variety Danda'a (moderately susceptible) there was no as much difference between unsprayed plots and one times spray which was, 0.67 and 0.66 respectively Figure 5. However, the SPC of three times spray on the variety Danda'a was very low (0.46), this probably may be due to the fungicide effectiveness and frequent fungicide application could minimize the septoria progress. On the variety Alidoro the highest SPC (0.62) was recorded on the unsprayed plots whereas, the lowest SPC on three times fungicide spray. This might be related with plant stature which means taller plant (Alidoro) varieties are less likely to increase the disease development from the lower plant part to the upper leaves (flag leaves) and the distance between two consecutive leaves also affect the vertical disease progresses (Lovell *et al.*, 2004) that Alidoro was being so. Similarly, Eyal *et al.* (1987) indicated that Septoria progress coefficient allows the comparison of infection placement or the position of pycnidia relative to plant height regardless of pycnidial coverage.



**Figure-5.** Septoria progress coefficient of three bread wheat varieties under different fungicide spray frequencies.  
Remark: SPC: Septoria progress coefficient.

## 4. CONCLUSION AND RECOMMENDATIONS

The disease pressure at Debre Tabor was very aggressive and starts infection at early growth stages than at Adet. This variation may be due to the environmental factors *i.e.* at Adet the rainfall was very low at latter growth stages, but at Debre Tabor there was a continuation of rainfall and relative humidity which was conducive for disease epidemics. And also, there may be a variation on the virulence level of local Septoria leaf blotch pathogen in the two locations. Varieties were responding to the pathogen differently. However, the variety Alidoro is also highly affected by the pathogen which was previously known as moderately resistant especially at Debre Tabor. Similarly at this location, the disease found to be much more important than at Adet, the reason behind might be due to the frequent rainfall and favorable environmental conditions throughout the growing season. The highest disease severity was found on the variety Gambo at both locations. Disease parameters like disease severity, progress rate, AUDPC, SPC, were high to the susceptible variety. However, further studies should be conducted at different environments to determine the level of disease epidemics for integrated disease management.

**Funding:** The Authors would like to thank the Amhara Agricultural Research Institute for the financial and technical support during the entire period of the study.

**Competing Interests:** The authors declare that they have no competing interests.

**Acknowledgement:** All authors contributed equally to the conception and design of the study. their great gratitude also goes to the Delivering Genetic Gain in Wheat (DGGW) project for funding this study.

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