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Survey of Septoria Tritici Blotch (*Septoria tritici*) of Bread Wheat (*Triticum aestivum* L.) in the Central Highlands of Ethiopia

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Abstract: **Septoria tritici blotch (STB) is an economically important foliar disease in the major wheat-growing areas of Ethiopia. The current research was conducted to determine the incidence and severity of STB in the central highlands of Ethiopia. A total of 59 wheat fields were surveyed in 27 districts of three administrative zones i.e. South west, west and North shewa zones. The overall mean incidence of STB across the three zones varied from 52 to 75 %. Similarly, mean severity ranged from 45 to 83 %. The present findings confirmed the importance of STB in Ethiopia.**

Keywords: **Bread wheat, Disease survey, Central Highlands of Ethiopia, Septoria tritici Blotch.**

1. INTRODUCTION

1.1.Back ground and Justification

Wheat (*Triticum* spp.) is considered among the most commonly cultivated cereal crops with over 755 million metric tons harvested each year (FAO, 2017). It is the fourth most important cereal crop in agriculture. Although the crop is widely cultivated at altitudes ranging from 1500 to 3000 m.a.s.l, in Ethiopia, the most suitable area falls between 1700 and 2800 m.a.s.l (CSA, 2017). Bread wheat (*Triticum aestivum* L.) accounts for approximately 20% of the totally consumed human food calories and provides the most stable food for 40% of the human population (Kumar *et al*., 2015). Ethiopia is the second largest producer of wheat in Sub-Saharan Africa after South Africa (Negasa *et al*., 2016). In spite of the production and yield increases, average grain yield of wheat is still low (<2.7 t/ha) and highly variable and below the world's average (3.09 t/ha) (FAO, 2017).

Crop yields are dependent on interactions of socio-economical, biological, technological and ecological factors. The ideal daily temperature for wheat development varies from 20-25^{0}C for germination, 16-20^{0}C for good tillering and 20-23^{0}C for proper plant development (Onwueme and Sinha, 1999). The crop can be grown in most locations where annual rainfall ranges from 250 to 1750 mm. About 75% of the wheat grown world-wide receives an average rainfall between 375 and 875 mm annually (Onwueme and Sinha, 1999; Bear *et al*., 2004). However, too much precipitation can lead to yield loss from diseases and poor root growth and development problems (Bear *et al.*, 2002).

Despite its importance as food and industrial crop, wheat production and productivity around the globe is hampered by a number of factors including biotic and abiotic stresses as well as low adoption of new agricultural technologies (Tesfaye *et al*., 2001). Of the biotic stresses, diseases caused by fungi are the most important factors constraining wheat production. Yellow rust (*Puccinia striiformis f.sp. tritici*), stem rust (*P. graminis f.sp. tritici*), leaf rust (*P. triticina*) and Septoria diseases especially *Septoria tritici* blotch (STB) are prevalent throughout the country (Endale *et al*., 2015). STB caused by the fungus *Septoria tritici* (*Mycosphaerella graminicola*), is a major disease of wheat in all wheat-growing

areas of the world causing serious economic losses (Eyal, 1999; Ghaffary *et al*., 2012). It is one of the most aggressive diseases on common wheat (*Triticum aestivum L*.) and durum wheat (*T. turgidum L. var. durum)* globally (Zillinsky, 1983; Kema *et al*., 1996). *Septoria tritici* blotch is by far the most important disease in Northern and Eastern Africa and the Middle East (Benbelkacem, 2016). However, according to Teklay *et al.* (2015), the prevalence and severity of the disease is more dependent on weather conditions of the season and varieties grown. The combination of mild temperatures with high humidity in areas, where susceptible wheat varieties are grown on large scale, creates the perfect conditions for the leaf blotch pycnidiospores to spread rapidly. The disease is one of the major constraints of wheat in all wheat-growing areas of Ethiopia, causing 42% economic loss annually (Abera *et al*., 2015; Ayele *et al*., 2006; Alemar *et al*., 2016).

Range of disease management options are recommended to control STB in wheat fields. Among these, cultural management options designed to reduce inoculum pressure are the first one. These include, rotation to non-hosts, field sanitation by deep plowing of crop debris inorded to decrease the amount of inoculum available to initiate a new disease cycle. This may be less effective on a field basis due to long-distance dispersal of ascospores, but may be helpful if coordinated within a region.

Bio-control has also been tested as another STB manamgement option. A collection of *Bacillus megaterium* originating from the wheat rhizosphere and leaves of barley, oat chaff, and grain have been screened for their ability to inhibit STB. Pseudomonads also have been tested as potential biocontrol agents (Ponomarkeno *et al*., 2011). Fungicides of various modes of actions have been recommended to manage STB but their use in Ethiopia has been limited mainly due to economic reasons.

Resistance in wheat to *Septaria tritici* has been demonstrated by a number of researchers, and breeding for resistance is likely to be the most practical method of controlling STB (Arama, 1996). Several sources of resistance have been reported but breeding for resistance has not always been successful in protecting wheat from the damaging effects of the disease; as expression of resistance is often correlated with morphological traits (Eyal *et al*., 1985). Moreover, wheat cultivars resistant in one part of the world may display susceptibility elsewhere. Even within a country, a difference observed in pathogen virulence that may be associated with fungal genetic variability (Eyal *et al*., 1985) is hindering the development of wheat varieties with broad spectrum of resistance. Resistance in wheat could be durable if the type of resistance in the variety is partial, which is polygenic, or non-specific to particular pathogen genotypes. Selection for partial resistance to STB may be restricted if that trait has a significant cost, for example reduced yield, which is the most important target for many wheat breeders.

Overall STB has remained an important constraint to wheat production all over the world including in Ethiopia. However, effective and sustainable management of the disease is yet to be achieved under Ethiopian condition. In Ethiopia, wheat is grown in different agro-ecological zones. The areas vary in-terms of weather conditions, wheat varieties grown and crop management practices. The crop contributed a great deal to the country as source of food and income but it is continuously ravaged by diseases and other biotic constraints. *Septoria tritici* blotch (STB) is one of the major diseases of wheat around the world and across wheat growing regions of Ethiopia. The disease occurs almost in all wheat growing places but its intensity varies from place to place due to variability in weather conditions, differential responses of wheat varieties to the disease and as a result of variations in crop management practices. Despite its importance, STB has been one of the most poorly understood pathosystems in Ethiopia. Thus far, only limited surveys were conducted in few areas. Yield loss assessment studies have been carried out in fewer areas and they are largely based on data from field surveys. As a result there is a need to assess the incidence and severity of STB in different regions and across agro-ecological zones to have a complete understanding of the importance of the disease in the country. Thus, this study was designed with the following objectives:

1.2.Genral objective

To contribute towards improved wheat production in the central highlands of Ethiopia through effective and sustainable manamgent of *Septoria tritici* blotch

1.3.Specific objective:

- ✓ To determine the incidence and severity of *Septoria trtici* blotch of bread wheat in the central highlands of Ethiopia

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2. MATERIALS AND METHODS

2.1. Survey of *Septoria tritici* Blotch (STB)

Disease surveys were carried out in the major wheat producing districts of North, South-west and West Shewa zones of Amhara and Oromia regional states. Survey districts in each zone were selected based on wheat area coverage. The surveys were carried out in 2016 main cropping season (from October to November) along the main roads and accessible routes in each survey district, and stops were made at every 5-10 km intervals based on vehicles odometers as per wheat fields available. A total of 59 wheat fields were surveyed across 27 districts.

2.1.1. Description of the study areas

The wheat septorial disease survey was carried out in North, West and South-west Shewa zones of Amhara and Oromia Regional State in Ethiopia (Table 1).

Table 1: Description of administrative zones included in the *Septoria tritici* blotch survey.

Zones	Number of fields assessed	Altitude (m.a.s.l.)	Latitude	Longitude
SouthWest Shewa	15	2072-2670	8º16-9º 56´N	37º 05´-38º46´E
West Shewa	17	2079-2868	8º10´-9º21´N	37º30´- 38º33´E
North Shewa	27	2283-3043	08º37"-09º66'N	38º30'-39º29'E

North shewa is located at 08º37'71"-09º66'94"N, 38º30'57"-39º29'83"E and with elevation ranges between 2283-3043 m.a.s.l. The area is characterized by a unimodal rainfall pattern and receives an average annual rainfall of 929 mm. The annual average maximum and minimum air temperatures are 21.4 and 9.0°C, respectively. West Shewa zone is located at 8º10´03´´-9º21´39´´N latitude and 37 º 30´25´´-38 º 33´01´´E longitudes and within elevation ranges between 2079-2868 m.a.s.l. Annual mean maximum and minimum rain fall is 1900 mm and 600 mm, respectively. The mean minimum and maximum air temperature of the area is 11.7°C and 25.4°C, in that order. South-west Shewa zone is located at 8º16-9º 56´N latitude and 37º 05´-38º46´E longitude and altitude ranging from 1600 to 3576 m.a.s.l. It receives annual rainfall ranging from 900 -1900 mm. The mean minimum and maximum air temperature of the area is 10ºC and 35°C, respectively.

2.1.2. Data collection and analysis

Depending on the size of the field, 5-10 spots in quadrant (2mx2m) were assessed in each field in "W" orientation. Disease prevalence and incidence data were obtained using the following formulae.

$$\text{Prevalence} = \frac{\text{No. of fields affected}}{\text{Total no. of fields assessed}} \times 100$$

$$\text{Disease incidence} = \frac{\text{No. of diseased plants}}{\text{Total no. of plants examined}} \times 100$$

The severity of *Septoria tritici* blotch was recorded using the double-digit scale (00–99) developed as a modification of Saari and Prescott's severity scale to assess wheat foliar diseases (Saari and Prescott, 1975; Eyal *et al*., 1987). The first digit (D1) indicates vertical disease progress on the plant and the second digit (D2) refers to severity measured as diseased leaf area. Percent disease severity is estimated based on the following formula:

% Disease severity (PDS) = ((D1/Y1) x (D2/Y2) x 100%),

Where D1 and D2 represent the score recorded (00-99 scale) and Y1 and Y2 represent the maximum score on the scale (9 and 9) (Sharma and Duveiller, 2007). The geographic coordinates (latitude and longitude), and altitude were recorded using Geographic Positioning System (GPS) unit. In Survey data (prevalence, incidence and severity) were analyzed by using the descriptive statistical analysis (means) over districts, varieties and altitude range.

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3. RESULTS AND DISCUSSION

3.1. Disease survey

3.1.1. Disease Prevalence

The current survey covered a wide range of areas located in the Central highlands of Ethiopia. From the 59 wheat fields assessed in the three zones, 99% were affected by the disease (Table4). STB prevalence ranged from 0 to 100% in North Shewa, averaging on 98%, while the disease prevalence was 100% in Southwest and West Shewa zones each. Abera *et al*. (2015) also reported 100% STB prevalence in their previous study.

Out of the 27 districts surveyed in the present study, STB was recorded in 27 districts with mean prevalence of 99%. Although STB appeared to be prevalent in the survey areas, both incidence and severity of the disease varied markedly across districts (Table 2). The overall distribution/prevalence of the disease in the 27 districts reached 100% except in Basona werena district, which had 75% disease prevalence. The high prevalence of STB in the survey areas could be attributed to weather conditions that are suitable to the disease development (frequent rains and moderate temperature) (Teklay *et al*., 2015).

3.1.2. Disease Incidence

The mean incidence of STB in the surveyed zones (South west, West and North Shewa) was 75%, 69% and 52%, respectively (Table2). Across the survey districts, STB incidence ranged between 38 and 100 %, averaging on 66%. The highest mean incidence (100%) was recorded in Welimera district of West shewa zone. This was followed by Lemen (South west zone), with 95% mean STB incidence and Ejere district, which had a mean STB incidence of 90%. Abera *et al*. (2015) also reported 80-98% STB incidence leading to up to 60% yield loss on susceptible wheat varieties. In addition, Endale *et al*. (2015) reported mean incidences of 90-100% in Toke Kuyara and Wolisso districts. The survey areas were categorized into two altitude groups based on their elevation. Group I, areas with altitude ranging between 1500-2000 m.a.s.l.,were considered as intermediate altitudes while the Group II areas, with altitude of >2000 m.a.s.l.,were considered as highlands. STB incidence was higher in the higher altitude areas than the low laying ones. The incidence of the disease was 66% at high altitude ranges. This could be due to favorable weather conditions for disease onset, development and spread.

3.1.3. Disease Severity

At the district level, the mean severity of STB ranged from 22% in Wokelo to 93% in Bechio district. The overall mean severity of the disease was 68% (Table 4). Our findings were more or less in agreement with Abera *et al*. (2015) that recorded overall mean severity of 54% in various districts of West and Southwest Shewa.The severity index in the surveyed areas ranges from 0.05 to 0.69 averaging on 0.59. The maximum severity index value (0.69) was recorded in Lemen and Kersamalima districts of South-west and Dendi districts of West Shewa zone. The minimum severity index (0.05) was obtained in Wekelo district of North Shewa zone. At the zonal level, STB was most severe in the Southwest (83%) and least severe (45%) in the Northern zone. This finding is in disagreement with Abera *et al*. (2015), who reported a mean severity of 53-55% in West Shewa and Southwest Shewa zones.

Table 2: Prevalence, incidence and severity of STB in Southwest, West and North Shewa Zones of Ethiopia in 2016 Cropping Season.

Zone	District	Altitude (m.a.s.l.)	Prevalence (%)	Incidence (%)	Severity (%)	PSI
South-west Shewa	Sebeta	2075-2235	100	65	63	0.22
	Lemen	2100	100	95	87	0.69
	Kersamalima	2107-2278	100	83	87	0.69
	Elu	2095	100	85	92	0.22
	Becho	2149-2289	100	80	93	0.33
	Weliso	2394	100	40	83	0.30
	Wenchi	2072-2670	100	76	86	0.59
	Chitu	2868	100	75	73	0.26
Mean/Range		2072-2868	100	75	83	0.30
	Ambo	2267-2650	100	68	57	0.43

	Guder	2079	100	60	83	0.30
	Tokekutaye	2261-2383	100	63	83	0.30
	Libenjawe	2292-2343	100	43	68	0.67
West Shewa	Dendi	2209-2472	100	73	87	0.69
	Ejere	2403-2600	100	90	71	0.09
	Welmera	2589	100	100	74	0.35
	Inchini	2687	100	60	82	0.20
Mean/Range		2079-2687	100	69	76	0.52
	Chenicha	2283	100	60	42	0.10
	Gorfo	2550-2565	100	50	39	0.33
	Muketuri	2584-2637	100	50	60	0.56
	DebreLibanose	2631-2665	100	40	74	0.35
	Degem	2979-3043	100	47	51	0.06
North Shewa	Wokelo	2596	100	40	22	0.05
	Deneba	2618-2697	100	38	33	0.11
	Basona werena	2697-2837	75	55	53	0.19
	Angolelanata	2930	100	67	53	0.19
	Sheno	2819	100	40	32	0.07
	Alelitu	2654-2815	100	80	40	0.37
Mean/Range		2531-3043	98	52	45	0.25
Grand Mean/Range		2072-3043	99	66	68	0.59

PSI= Percent Severity Index

3.1.4. Intensity of STB on various wheat varieties commonly grown in the survey areas

Almost all of the bread wheat varieties grown in the study area were susceptible to STB. A total of five different wheat varieties were found to be commonly cultivated across the survey areas. None of the varieties were resistant to STB but disease incidence and severity varied across the varieties. Overall STB incidence varied between 0 and 100% while disease severity ranged from 0 to 93% (Table 5). Average STB incidence was the lowest (34.17%) on variety Kekeba and the highest (90%) on Kubsa. Mean STB severity was the lowest (18.52%) on the local variety and the highest (60.49%) on Kubsa, a variety which also had the highest incidence of STB. This finding is in line with Abera *et al*. (2015), who reported susceptibility of all wheat cultivars grown in surveyed areas. Current results suggest the vulnerability of imporved wheat varieties to STB although results need to be confirmed with additional studies. STB causing up to 82% yield loss on released varieties were reported in previous studies (Eshetu, 1986; Mengistu *et al*., 1991; as cited in Abreham, 2008; AARC, 2000; .KARC, 2005). The population of *Septoria tritici* blotch is highly diverse genetically and the fungus may reproduce sexually several times during the wheat-growing season (Kema *et al*., 1996; McDonald *et al*., 1999; Teklay *et al*., 2015). The planting of diverse and susceptible wheat varieties in the wheat producing areas of the country may provide a perfect medium for the multiplication of highly aggressive races of the pathogen that may threaten wheat production in the study areas and beyond. According to Sharma *et al*. (2002), a high degree of variability at the lesion sampling level and a low degree of variability at the leaf and location sampling levels suggest that the primary source of inoculum was mostly air-borne aeciospores. As a result due attention should be given to the deployment of varieties that possess broader spectrum of resistance to STB. Addition to this, wheat variety grown, planting dates, previous crop/s, and any control measures applied by the farmers were recorded.

Table 3: Incidence and severity of STB on various Bread weat varieties.

Variety	Altitude (m.a.s.l)	Incidence(%)		Severity			
		Range	Mean	Range (%)	Mean (00-99)	scale	Mean(%)
Kubsa	2079-2670	0-80	90	21-93	77.11		60.49
Kekeba	2107-2697	0-80	34.17	0-87	37.33		25.93
Dendaa	2072-2930	20-100	64.44	25-92	44.67		24.69
ET-13	2283-2786	40-60	53.33	42-64	53.67		24.69
Digelu	2209-3043	10-100	65.91	22-93	56		37.04
Local	2596-3036	40-80	64	22-62	52.75		18.52

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4. CONCLUSION AND RECOMMENDATION

Bread wheat (*Triticum aestivum* L.) is one of the most important cereal crops in Ethiopia. It is widely grown in most of the regions in the country, including the Central highlands. However, its production is affected by abiotic and biotic factors. Among the biotic factors, *Septoria tritici* blotch (*Septoria tritici*) (STB) is one of the important problems of wheat production in the country. Despite its importance, STB has been one of the most poorly understood pathosystems in Ethiopia. As a result, the present study was conducted to assess the incidence and severity of STB in different regions and across agro-ecological zones to have a complete picture on the importance of the disease in the country. The major objective of the study was to contribute towards improved wheat production in the central highlands of Ethiopia through effective and sustainable manamgent of *Septoria tritici* blotch. Disease surveys were conducted in the major wheat producing districts of North, Southwest and West Shewa zones of Amhara and Oromia regional states. Across the survey districts, STB incidence ranged between 38 and 100 %, with an average of 68%. The overall mean severity of the disease was 67.91%. The maximum severity index value (0.69) was recorded in Lemen and Kersamalima districts of Southwest and Dendi districts of West Shewa zone; while, the minimum severity index value (0.05) was obtained in Wekelo district of North Shewa zone. Our results also confirmed susceptibility of almost all bread wheat varieties under production in the study area to STB. Current results also suggest the vulnerability of improved wheat varieties to STB although results need to be confirmed with additional studies.

Dedication

It is dedicated to my father Tadesse Demisse and mother Darunesh Bayu, whom I lost them when I was a teenager and my brothers Wondoson Tadesse and Fikadu Tadesse and my sister Etabezahu Tadesse who filled the role of my lost parents.

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