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Survey of Septoria Leaf Blotch (*Septari atritici* Roberge in Desmaz) on Wheat in North Gondar, Ethiopia

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ABSTRACT

Wheat, an important cereal crop of Ethiopia facing challenges in production by lack of appropriate agronomic practices, weather uncertainties, weeds, insects and diseases outbreaks. Septoria leaf blotch a common disease inflicts heavy qualitative and quantitative losses. The objectives were to assess the distribution, incidence and severity of septoria leaf blotch and its association with biological and physical independent factors in North Gondar Ethiopia. A total of 113 fields in 2014 and 2015 years were randomly assessed for wheat diseases. Disease incidence and severity were described statistically and the association of septoria disease incidence and severity with independent variables was analyzed using logistic regression. The mean incidence and severity of *Septoria tritici* in North Gondar during the assessment years was 34.7% and 17.5%, respectively. The mean highest severities were recorded at flowering, on local varieties, on previously legume sown, brown cambisol soil of poorly managed fields. Variables such as district, variety, growth stage, altitude, previous crop, and soil type and field management were significantly associated with the septoria incidence. Similarly, all the variables were significantly associated with *Septoria tritici* severity in logistic regression model. Other wheat diseases observed were rust (yellow rust, stem rust and leaf rust), loose smut, head blight and premature drying. Results indicate that septoria leaf blotch is a major biotic constraint in the study area and proper field management, in addition to improved wheat varieties, can reduce the risk of septoria leaf blotch. Furthermore, disease management measures suitable for small-scale wheat growers in study area are required.

Keywords: Wheat, Septoria, Severity, Incidence, Variables.

INTRODUCTION

Wheat (*Triticum aestvium* L.) is among the major cereal crops cultivated in Ethiopia. It was cultivated in about 1.71 million hectares of land with productivity of 2.63 tons per hectare (Central Statistics Authority, 2017). This low yield is attributed to multi-faced abiotic and biotic factors such as lack of improved varieties, low and uneven distribution of rainfall, poor agronomic practices, insect pests and diseases (Dereje & Yaynu, 2000). Among the biotic yield limiting factors, diseases are the most important; of these Septoria leaf blotch (*Septiria tritici*), Rusts (*Puccinia spp*), Fusarium head blight (*Fusarium gramnearum*), Leaf spot (*Helminthosporium spp*) and Tan spots (*Helminthosporium tritici*-repentis) are the foremost diseases (Ayele & Temesgen, 2008).

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Septoria leaf blotch is characterized by irregular necrotic lesions interspersed with small black fruiting bodies (Pycnidia) on the leaves (Palmer & Skinner, 2002) and stem (Ponomarenka et al., 2011). It is these lesions that reduce the green leaf area of the plant and which, particularly if present on the upper leaves during grain filling, can reduce yield (Gooding et al., 2000). Under favorable growing-conditions, yield losses can reach 30-53% (Lendenmann et al., 2014), especially with high-yielding and susceptible cultivars (Mehrabi et al., 2014). This higher yield loss could be reached in regions with high relative humidity (85%) and optimum temperate between 20 and 28 degrees centigrade (Dalvand & Roohparvar, 2013). In Ethiopia the yield loss of 25 to 41% incurred at Holeta agricultural research center on susceptible wheat cultivars (Takele et al., 2015). Fungicides application and the development of resistant wheat cultivars are the strategies to alleviate septoria leaf blotch (Eyal et al., 1987).

Because Septoria leaf blotch is a constant threat to wheat-growing areas of Ethiopia, it is prudent to quantitatively determine its distribution, associated pathogens and factors affecting disease development. Moreover, disease monitoring and surveillance are of essential for timely devising the control measures and tackle food insecurity. Hence, this study assessed the distribution and destruction of septoria leaf blotch and its association with biological and physical factors in the major wheat growing area of North Gondar, Ethiopia.

MATERIALS AND METHODS

Survey area:

Survey of Septoria leaf blotch were conducted in six major bread wheat growing districts of north Gondar zone, namely Dabat, Debark,Wogera, Lay Armachiho, Dembia, Takusa and Gondar zuria during the 2014 and 2015 main cropping season (Fig. 1). They are located between 11^0 27'31" - 13º46'10"´N latitude and 35^0 16'41"-38º46'30"E longitude with altitude range of 560-4630 m.a.s.l. The annual average rain fall was 1115mm. The mean maximum and minimum temperature of the area is 10^0C and 42°C, respectively. The districts have a unimodal rainfall and extend from June to the end of October.

Diseases Assessment:

A total of 113 bread wheat fields were randomly assessed for septoria leaf blotch and other wheat diseases. The survey was done once in 2014 and twice in 2015 from stem elongation to dough growth stages. Bread wheat fields were randomly sampled at intervals of 5–10 km along the main and feeder roads. In each fields, data were taken randomly at 15 meters interval once at three points along the diagonal of the field using $1m^2$ quadrat. Disease incidence was recorded as the percentage of plants showing septoria leaf blotch symptoms in each quadrat, and the averages of the three quadrats were calculated for each field.

Septoria leaf blotch severity was recorded using double digit scale (Saari & Prescott, 1975). Double digit disease scale measures overall foliar infection on the whole plant on the basis of two digit (00-99), where, the first digit scale (0-9) equated to the height of infection on plant, and the second digit stand for disease severity. The scale gradations were expressed in 1 to 9 scales (1=10%, 2=20% and 9=90%) in both the parameters. The disease severity percentage was calculated based on the following formula (Sharma and Duveiller, 2007).

Disease severity (%) = $(D_1/9) \times (D_2/9) \times 100$,

Where, D_1= First digit (height of infection) and D_2= Second digit (severity of infection).

To do an association of septoria leaf blotch besides the disease severity data, agronomic practices were recorded on each field. Variety grown whether local or improved, previous crop (legume, cereal and fallow) were collected through interview and assessment. Field management as good, fair and poor was taken to determine weed density. Altitude (1800-2300 and >2300masl) of each field was measured using GPS. Soil type (Vertisol or Cambisol), and growth stage (dough, flowering, booting and stem elongation) were recorded in

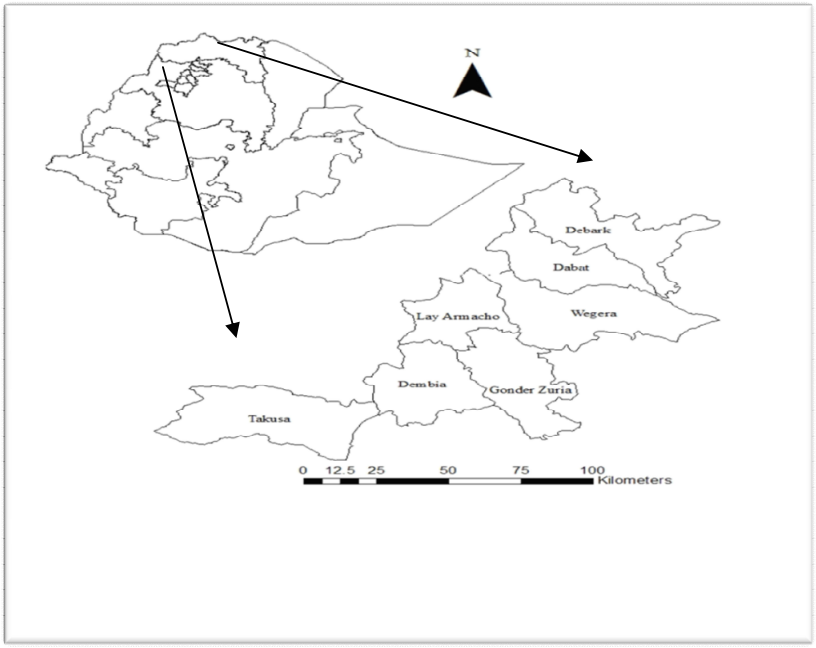

Fig. 1: Map showing surveyed districts for septoria leaf blotch of wheat in north Gondar, Ethiopia

each fields. Other biological and physical factors like the growth stage, variety, preceding crops, field management, elevation, soil type and crop season were recorded.

Data analysis:

The disease severity was classified in two whether or not the levels of infestation exceed 25% severity and 50% incidence. Based on this, the disease intensity was categorized into two main groups to generate binary dependent variable. A contingency table of disease severity by independent variables was built to represent the bivariate distribution of fields (Table 1).

Disease incidence and severity were described using the Statistical Analysis System (SAS). The association of septoria disease incidence and severity with independent variables was analyzed using logistic regression as described by McCullagh & Nelder (1989); Fininsa & Yuen (2001); Sahile et al. (2008) with the SAS procedure GENMOND. The logistic regression model assesses the importance of multiple independent variables that affect the response variable. It calculates the probability of a given binary out come as a function of the independent variables. The binary outcome was the probability that septoria severity exceeds 25% and incidence exceeds 50% in a given wheat field. The SAS procedures GENMOND and logistic were used to estimate the parameter estimates. Exponentiation the parameter estimates of each variable class results the odds ratio, which are interpreted as relative risk that is the higher the odds ratio of a variable the higher diseases infestation (Yuen et al., 1996).

The importance of the independent variables (risk factors) was evaluated in two ways; first the association of an independent variable alone with septoria leaf blotch incidence or severity was examined. In the other method, independent variables with high association to septoria incidence or severity were added to reduce multiple variable model. Deviance reduction was calculated for each variable as it was added to the reduced model and likelihood ratio test was used to examine the importance of the variable and was tested against χ^2- value (McCullagh & Nelder, 1989).

Table 1. Categorization of variables used for logistic regression analysis of septoria leaf blotch in wheat fields (n = 113) during the 2014 and 2015 cropping season, North Gondar, North West Ethiopia

Independent variable	Variable classes	Number of fields with Septoriatritici			
		Incidence (%)		Severity (%)	
		≤50	>50	≤25	>25
Districts	Debark	19	10	19	10
	Wogera	9	11	11	9
	Lay Armachiho	2	0	2	0
	Gondar	6	2	6	2
	Dembia	7	0	7	0
	Gondar Zuria	4	2	6	0
	Chilga	8	0	7	1
	Takusa	4	0	4	0
Growth stage	Flowering	4	1	1	4
	Booting	32	0	30	2
	Dough	32	31	37	26
	Stem elongation	12	1	11	2
Variety	Local	21	15	18	19
	Improved	58	18	61	15
Previous crop	Legume	42	27	40	29
	Cereal	29	6	30	5
	Fallow	9	0	9	0
Soil	cambisol	61	31	65	29
	vertisol	19	2	16	5
Field management	Good	28	10	27	11
	Fair	36	19	37	18
	Poor	16	4	15	5
Altitude	1800-2300masl	26	2	27	1
	>2300masl	54	31	52	33
Year	2014	24	15	39	25
	2015	56	18	54	20

RESULTS

In North Gondar farmers produce improved wheat varieties than local varieties on previously legume sown fields especially on brown type soils potentially in the high land districts (Dabat, Debark and Wogera). Septoria leaf blotch was found to be among the most destructive disease observed during the growing season across surveyed areas (Table 2). As to the survey wheat septoria leaf blotch was the major prevalent and destructive diseases in both cropping season in the zone. The mean incidence and severity of septoria leaf blotch in North Gondar during the assessment years was 34.7% and 17.5% respectively. The highest infestation of septoria leaf blotch (43.1%) and severity (19.75%) on wheat was scored in the year 2014 cropping season (Table 5).

The association of independent variables with septoria leaf blotch incidence and severity were presented on Table 3. Variables such as district, variety, growth stage, altitude, previous crop, soil type and season were significantly associated with the septoria incidence. However field management was not important as single predictor in the logistic regression model for both intensities. Similarly, all the variables were significantly associated with septoria leaf blotch severity.

Table 2.Mean disease incidence and severity of wheat septoria leaf blotch for different independent variables in 2014 and 2015 cropping seasons, North Gondar zone

Independent variable	No.of fields	Disease Incidence (%)				Severity (%)			
		Mean	Min	Max	SD	Mean	Min	Max	SD
Districts									
Debark	29	36.6	0	100	39.3	19.3	0	70	21.2
Dabat	29	36.5	0	100	38.9	21.7	0	60	20.5
Wogera	20	57.5	0	100	40.5	26.0	0	70	20.4
Lay Armachiho	2	5	0	10	7.1	5	0	10	7.1
Gondar	8	25	0	100	46.3	12.5	0	70	25.5
Dembiya	7	0	0	0	0	0	0	0	0
Chilga	8	1.25	0	100	2.3	5	0	30	10.7
Takusa	4	0	0	0	0	0	0	0	0
Gondar Zuria	6	33.3	0	100	51.6	5	0	20	8.4
Growth stage									
Flowering	5	38	0	100	39.6	36	0	70	26.1
Booting	32	2.7	0	30	6.8	3.5	0	30	8.3
Dough	63	52.1	0	100	42	23.7	0	70	21.2
Stem elongation	13	10	0	55	17	8.5	0	40	12.8
Variety									
Local	37	48	0	100	43.4	27.6	0	70	21.7
Improved	76	25.2	0	100	36.4	11.5	0	70	17.4
Previous crop									
Legumes	69	43.8	0	100	40.8	22.6	0	70	21.3
Barley	35	19.1	0	100	35.2	9.4	0	60	15.9
Soil									
Cambisol	92	36.9	0	100	41.8	18.2	0	70	21
Vertisol	21	14.3	0	100	25.1	10.5	0	50	15.6
Field management									
Good	38	26.8	0	100	35.9	14.5	0	50	17
Fair	55	36.1	0	100	42.9	17.8	0	70	21.3
Poor	20	30.8	0	100	38.5	16.3	0	70	20.7
Altitude									
Mid (1800-2300masl)	28	7.5	0	100	26.2	2.5	0	30	7
High (>2300)	85	40.9	0	100	40.5	21.4	0	70	21.1
Year									
2014	39	43.1	0	100	44	19.7	0	70	22.4
2015	74	27.2	0	100	37	15.1	0	70	19

DISCUSSION

Among the wheat fields a severity range of 0% to 26 % was recorded. The highest mean severity (26%) was recorded in Wogera districts followed by Dabat (21.7%) while the lowest severity (0%) was in Dembia and Takusa (mid altitudes) districts

Table 3.Independent variables used in logistic regression modeling of wheat septoria leaf blotch incidence and severity and likelihood ratio test (LRT) as single predictor of disease outcome

Independent variable	df	septoria leaf blotchincidence LRT>50%		septoria leaf blotch severity LRT>25%	
		DR	Pr>χ^2	DR	Pr>χ^2
District	8	8019.6	<0.0001	2698.1	<0.0001
Altitude	1	6890.4	<0.0001	2380.0	0.0291
Soil	1	6857.4	<0.0001	2362.8	0.0007
Variety	1	6795.4	<0.0001	2224.4	<0.0001
Growth stage	3	4736.9	<0.0001	1674.2	<0.0001
Previous crop	2	4651.49	<0.0001	1637.1	<0.0001
Field management	2	4650.6	0.6496	1635.8	0.5015
Year	1	7120.1	<0.0001	2479.4	<0.0001

df = degree of freedom, DR = deviance reduction, Pr = Probability of $\chi 2$ value exceeding the deviance reduction, LRT = likelihood ratio test

during the cropping seasons. The mean highest severities were recorded at flowering, on local varieties, on legume previously sown, this could be due to the fixation of nitrogen with legumes as nitrogen level increase the diseases can aggravate, on cambisol soil and poorly managed fields. Agronomic practices also influence leaf blotch severity by modifying the microclimate within the crop canopy (Shaw & Royle, 1989) or the nitrogen (N) concentration in the leaves (Leitch & Jenkins, 1995), but the magnitude and direction of these effects are inconsistent. Increased N fertility has been reported to increase the severity of the disease (Howard et al., 1994; Leitch and Jenkins, 1995). Johnston et al. (1979) reported a decrease in the severity of the disease with increased N in 1 year of their experiments. The incidence of several wheat diseases depends on the form in which N is applied (Huber & Watson, 1974). Thus, although N seems to influence the severity of the leaf blotch, there is no clear correlation as to how the influence is expressed as the conditions of the experiments have been very different. Therefore, N effects, on Septoria leaf blotch could have been interacting with climate, soil type, N dose applied, canopy structure, previous crop, time of application, cultivar resistance and available natural inoculums (Leitch and Jenkins, 1995). A highest mean severity (19.7%) of septoria was recorded in the year 2014 cropping season than 2015 cropping season due to the high rain fall in 2014. The disease infestation range from the bottom leaves to the flag leaf. A maximum incidence of 100% was recorded on the higher altitude and a mean maximum incidence of 57.5% was recorded at Wogera district (Table 2). The overall mean septoria leaf blotch incidence and severity of 35.1% and 17.4% were recorded in bread wheat growing area of the surveyed area, respectively (Table 5). Similar study on septoria leaf blotch in central Ethiopia show 64-100% disease incidence and 45-77% of severity on wheat fields (Hailu & Woldeab, 2015).

All variables were tested in a reduced multiple variable model with septoria leaf blotch severity as the dependent variable. For added variables analysis of deviance, parameter estimates, standard errors resulting from the reduced regression model are given in Table 4. Lower septoria severity (≤25%) had shown that a high probability of association at stem elongation (1) and booting growth stages (0.734), altitude (<2300 masl) (1.2E-11), cambisol soil (0.63), improved varieties sown fields (0.54) while their compared variable classes flowering (7.79) and dough (4.6) growth stages, altitude (>2300) (1), vertisol soil (1), local varieties (1) had higher probability of association to septoria severity (>25%) as this variable classes have higher odds ratio (Table 4).

Other wheat diseases observed during the survey were rust (yellow rust, stem rust and leaf rust), loose smut, head blight and premature drying. 4% yellow rust infestation and severity of 2.3% were scored on the year 2014 cropping season and a very low infestation was recorded on 2015 cropping season. On 2014 cropping season up to 4% stem rust incidence and a severity of 2.3% were recorded and samples were sent to Ambo plant protection center for race analysis as the

result a stem rust race known as TKTTF (code for rust race analysis) was analyzed in North Gondar. In 2013, Ethiopia experienced localized but sever previous crop, soil type and weed density were significantly associated with the disease incidence and severity. The analyses of the association of

Table 4. Analysis of deviance, natural logarithms of odds ratio, odds ratio and standard error of added variables in a reduced model predicting septoria leaf blotch severity less than 25%

Added variable	df	LRT		Variable class	Estimate $Log_e^{(OR)}$	SE	Odds ratio
		DR	Pr>χ^2				
Intercept					-20.0605	0.3625	1.94015E-09
Growth stage	1	1674.2	<0.0001	Flowering	2.0526	0.1632	7.788123927
				Booting	-0.3087	0.1539	0.734401057
				Dough	1.5309	0.1178	4.622335052
				Stem elongation	0.0000	0.0000	1
Altitude	1	2380.0	<0.0001	1800-2300	-25.1266	0.0000	1.22365E-11
				>2300	0.0000	0.0000	1
Soil	1	2362.8	<0.0001	Cambisol	-0.4625	0.0976	0.629707408
				Vertisol	0.0000	0.0000	1
Previous crop	1	1637.1	<0.0001	Legume	22.2111	0.0824	4427495893
				Barley	22.3	0.0000	4839126180
				Fallow	0.0000	0.0000	1
Variety	1	2224.4	<0.0001	Improved	-0.6263	0.0589	0.534566041
				Local	0.0000a	0.0000a	1
Year	1	2479.4	<0.0001	2014	-0.0267	0.0747	0.973653294
				2015	0.0000	0.0000	1

Table 5. Mean severity and Incidence of Septoria and Other diseases in 2014 and 2015 cropping season in North Gondar

Year	Septoria leaf blotch (%)		Yellow rust(%)		Stem rust (%)		Leaf rust (%)		Loose smut (%)	Premature drying (%)	Head blight (%)	
	I	S	I	S	I	S	I	S	I	I	I	S
2014	43.1	19.75	3.9	2.3	3.6	2.3	8	1.2	0.1	1.6	3	0.2
2015	26.2	15.2	0.5	2	-	-	-	-	0.03	1	0.5	0.3
Mean	34.7	17.5										

I=Incidence and S=Severity

stem rust epidemics in southern wheat production region and the epidemic continued into the 2014 crop season (Olivera et al., 2015). Singh et al. (2015) reported, race analysis of sample from the epidemic regions detected race TKTTF to be the causal race behind these epidemics. Race TKTTF is highly virulent to the widely grown Digalu wheat, which possesses resistant gene *SrTmp* that is effective against the Ug99 race group and ineffective against TKTTF. Diseases like leaf rust, loose smut, premature drying and head blight were also recorded but with low infestation (Table 5).

In conclusion, the study indicated that wheat septoria leaf blotch was the major prevalent and destructive diseases in both cropping season in major wheat growing area of North Gonder of Ethiopia. The mean disease incidence and severity of septoria leaf blotch in the area were 34.7% and 17.5%, respectively. A maximum disease incidence (100%) and severity (70%) was recorded. Variables such as variety, growth stage, altitude, biological and physical factors with septoria leaf blotch suggest that designing appropriate technologies to alleviate seasonal disease problem is important. Proper field management, in addition to improved wheat varieties, can reduce the risk of septoria leaf blotch. Hence, breeding for resistance to septoria leaf blotch should be given high priority. Furthermore, disease management measures that are suitable for adoption by the small-scale farmers who are the major growers of wheat in the region are important. In addition, differential test should be conducted year to year to determine the race composition and virulent.

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