

Distribution and Importance of Barley (*Hordeum vulgare*) Fungal Diseases in Ethiopia

Tajudin Aliyi Mohammed*, Bayoush Birke Yeshnigus, Alemayehu Hailu Welderufael

Plant Pathology, Ethiopian Institute of Agricultural Research, Ambo Agricultural Research Centre, Ambo, Ethiopia

Email address:

tajudinaliyi2014@gmail.com (T. A. Mohammed)

*Corresponding author

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Abstract: Biotic factors were of the bottleneck elements that contributed to yield reduction of Barley in Ethiopia, including fungal, viral and bacterial diseases. However, fungal diseases were the most significant important compared to others. The major constraints of Barley production in the country were diseases. This study was aimed to identify, document, prioritize and know the distribution of fungal diseases of Barley in Ethiopia, to map the spatial distribution area for economically important Barley diseases. Field surveys were carried out at the period of 2017 and 2018/19 main growing season in major Barley growing agroecological zones of the country. From each representative zone of major growing areas, districts were surveyed based on production of Barley fields each averaging 1 ha at the interval of 5-10 km along road side. Each sampling point was checked with the global positioning system (GPS) using GPS receiver for altitude and co-ordinates. Survey results revealed the prevalence and intensity of different diseases of Barley across all the districts even though at different levels. Among 101 observed fields, Scald was the most prevalent (79.2%) while the overall mean maximum incidence was recorded for Spot blotch (68.4%), the highest percent severity (9.5%) was recorded for loose smut. Initiation of integrated diseases management option at hot spot area of each disease was suggested, in addition to continuously evaluating the new sources of Barley genotypes for further breeding program.

Keywords: Barley, Fungi, Diseases, Intensity, Prevalence, Survey

1. Introduction

Crop diseases, which include fungal, bacterial and viral diseases, have been causing economic damage to the Ethiopian agriculture. Particularly, in the smallholder agriculture, which contributes to about 95% of annual crop production in the country, crop losses due to fungal diseases causing pathogens are a serious concern where in most cases they have limitation both in technical know-how and financial resources to apply effective pest control tactics and reduce crop damages [1].

Barley (*Hordeum vulgare*) is an important commodity and has a long history of cultivation and diverse agro-ecological and cultural practices in Ethiopia [2]. Barley is known to be an important staple food, industrial crop and animal feed worldwide, ranking fourth after wheat, maize and rice [3]. In Ethiopia, Barley covered for 7.39% (0.95 million hectares) of the 81.46% (10.48 million hectares) of cereals and produced

2.4 million tons of grain, with 2.5 t ha⁻¹ [4]. Although Ethiopia is a center of diversity for barley, most of the country's farmers still obtain very low yields due to a combination of biotic and abiotic constraints. Barley productivity in the country, however, is very low (2.5 t ha⁻¹) [4] compared to that of most other countries (3 to 4 t ha⁻¹) due partly to biotic and abiotic factors and other factors influencing yields negatively [5, 6].

Diseases like scald, net blotch, spot blotch, and rusts, which can reduce yields by up to 88.98 percent, are among the major biotic stresses [7, 8]. Due to the fluctuation of environmental condition and the development of pathotypes of pathogens causing different types of diseases on barley, epidemics and importance of diseases may vary from season to season and year to year. However, this information was lacking over the last decades in Ethiopia. Thus this study was designed to identify newly emerging pathogens, document and prioritize the status of already reported barley infecting

pathogens to know if there is any shift in importance.

2. Materials and Methods

Field surveys were carried out during the 2017 and 2018/19 main growing season in major Barley growing agro-ecologies in Ethiopia. Barley crop in major growing agro-ecologies were assessed to determine prevalence, incidence and severity of diseases. Zones and districts were selected based on the differences in farming systems; weather condition (Relative humidity, maximum and minimum temperature), and major vegetation cover. However, some farming systems tend to overlap between districts. From each representative zone of major Barley growing areas, on the average 1 ha of fields were surveyed at the interval of 5-10 km along road sides. Such fields were randomly selected on both sides of the road. The global positioning system (GPS) was used to mark each sampling point using a GPS receiver for altitude and co-ordinates. Five stops were sampled in each Barley field by moving in 'X' fashion using 1×1 meter square quadrants and data were collected from individual quadrants and the five samples per fields were averaged and used as one site. Prevalence of a disease was calculated using the number of fields affected divided by the total number of field assessed and expressed in percentage.

$$\text{Prevalence (\%)} = \frac{\text{Number of infected fields}}{\text{Total number of fields assessed}} * 100$$

Disease incidence was assessed as proportion of plants showing symptoms in the field. The number of plants randomly selected stand showing each disease symptoms were counted and expressed as a percentage of the total number of stands per plot using the following formula:

$$\text{DI(\%)} = \frac{\text{Number of Diseased plants}}{\text{Total number of plants observed}} * 100$$

Disease severity on individual plant basis was rated using a visual scale recommended for each disease on Barley crop [9, 10]. Severity scores were converted to percent disease index, PDI, [11, 12].

$$\text{PSI(\%)} = \frac{\text{Sum of numerical rating}}{\text{Total number of plant observed} * \text{maximum rating}} * 100$$

Disease data (incidence and severity) were entered into Excel to calculate means and percentages. Disease distribution maps were generated using the Arc GIS 10.3 software with spatial analyst by interpolating the surface from GPS points and the associated field severity data using the inverse distance weighted (IDW) interpolation method.

Finally, identification of causal agents of fungal diseases was made based on symptom in the field and confirmed with microscopic examination in laboratory using standard procedures suggested for both biotrophic and necrotrophic fungi in Mycology laboratory at Ambo Agricultural Research Centre.

3. Results and Discussion

3.1. Prominence of Major Fungal Diseases of Barley in Studied Areas During 2017 and 2018/19 Main Growing Season

Nine fungal diseases were identified from barley fields assessed in major barley growing agroecological zones in Ethiopia. Among 101 fields inspected, Scald (*Rhynchosporium secalis*) was the most prevalent (79.2%) followed by Net blotch (*Pyrenophora teres*) (48.5%) and Leaf rust (*Puccinia hordei*) (34.7%). Net blotch is one of the most important barley diseases which reduce both quality and quantity of barley grain [13]. The overall maximum mean disease incidence recorded were 68.4% 56% and 55.5%, respectively, for spot blotch, powdery mildew and scald. On the other hand, relatively, highest overall mean percent severity of 9.2% for Net blotch and 9.5% for loose smut were scored (Table 1). Overall, the incidence and severity of net and spot blotch diseases were 26.6 percent and 25 percent, respectively, and 29 percent and 16 percent [14]. Bekele [8] reported that in detailed disease survey in north east Ethiopia, the most prevalent and severe in all areas, in both *Meher* and *Belg* seasons were Net blotch and Spot blotch. They also noticed that the highest net blotch intensity on main season compared to off-season. Similarly, Net blotch and Spot blotch considered as major diseases of barley in western Ethiopia. In this area scald disease recorded 81.5% prevalence, 19.1% incidence and 4.63% severity [8]. In the current investigation, of 101 surveyed fields for barley diseases and samples tested in Mycology laboratory, scald prevalence, incidence and severity were, respectively, 79.2% 55.5% and 7.3%.

In addition to the aforementioned diseases, covered smut, loose smut and septoria leaf blotch were becoming major diseases in some surveyed Barley growing agroecological zones at study period in the main seasons.

3.2. Distribution of Diseases in Surveyed Areas in 2017 and 2018/19 Main Growing Seasons

Geographical distribution of fungal diseases infecting Barley in surveyed areas during the seasons showed that the importance and variation of diseases intensity from site to site based on environmental conditions for each disease (Figures 1-4). Scald and Net blotch were more important in most districts studied in West and South West Shewa zones of Oromia region and North Shewa zone of Amhara region. The disease maps demonstrate spatial patterns of epidemics for major barley diseases with some districts showing high variation in intensity of scald, net blotch, spot blotch and rust (Figures 1-4). The disease maps exemplify severity and incidence levels of major barley diseases over the agroecology covered and were used to show epidemic patterns during the study periods.

In the present study percent incidence for Scald ranged from 3-100% while percent severity ranged from 1-60% (Figure 1). The Scald incidence recorded in vast majority of

districts in different zones was 90% and above. Relatively maximum disease incidences (90-100%) were recorded in west shewa and South west shewa zones of Oromia region and north shewa zone of Amhara region. In similar manner, Scald was more severe in few districts of west shewa and south west shewa zones in oromia and north shewa zone in Amhara region where percent severity recorded ranged from 50-60%. Severities ranging from 30-40% were also recorded in some districts of north Shewa zone in Amhara and few districts of west shewa in Oromia. In contrast, the low level of incidence (3-10%) were observed in some studied areas across the country, For example, low disease incidences were recorded in few districts of South west shewa and East shewa zones of central oromia. In spite of this, no field was free of the disease i.e. at least one fungal disease attacked the crop in the field observed at the study period (Figure 1).

Diseases Incidence for Net blotch varied from 3 to 100% whereas the severity fluctuated between 1% and 60%. Hence, areas in few districts of north Shewa zone of Amhara region, and north, west and east Shewa zones of Oromia region scored high disease incidence (71 to 100%) compared to other areas. On the other hand percent net blotch severity ranged from 21-60% in West Shewa and few districts of North Shewa in Amhara region while most of the surveyed

areas (i.e. most districts of West Shewa and South west Shewa as well as few districts of North Shewa in Oromia and Amhara) felled under low net blotch severity, ranging from 1-5% (Figure 2).

Percent incidence of Spot blotch also varied from 10 to 100% and based on the incidence data, it was important in East Gojjam, North Shewa, West Shewa, and South West Shewa zones (Figure 3). Leaf rust was distributed in West Shewa, South west Shewa and North Shewa zones (Figure 4). The variation of the diseases intensity from one vicinity to other and/or from one barley agroecological zones to another might be due to the differences in cropping system, susceptibility of the cultivars, environmental factors such as temperature, rainfall, relative humidity, etc. that could be aggravated the outbreak of the diseases epidemics.

It's difficult to predict the impact of climate change on the distribution of crop pathogens, disease risk and severity, and management guidelines because of the complex interactions between crop host, pathogen, and environment. Variations in precipitation, temperature, and increased atmospheric carbon dioxide concentration are the main climate factors. Any disease could become more important if the climate shifts in the pathogens' favor [15].

Table 1. Over all mean prevalence, incidences and severity of Barley fungal diseases across Ethiopia during the 2017 and 2018/19 main cropping season.

Diseases	N ^o of Zones	Total Number of fields	Altitude Range (masl)	Temp. (°C)	OMP (%)	OMI (%)	OMPDI (%)
Scald (<i>Rhynchosporium secalis</i>)	3	101	2254-3334	20-32.2	80 (79.20)	55.54	7.25
Net blotch (<i>Pyrenophora teres</i>)	3	101	2254-3317	19-32.5	49 (48.51)	51.796	9.18
Leaf rust (<i>Puccinia hordei</i>)	3	101	2458-3220	17-32.5	31 (34.65)	38.057	2.37
Spot blotch (<i>Cochliobolus sativus</i>)	3	101	2251-3317	19-32.5	28 (27.72)	68.39	3.43
Covered smut (<i>Ustilago hordei</i>)	3	101	2251-3220	19-26	23 (22.77)	26.52	2.74
Powdery mildew (<i>Erysiphe graminis</i> f. sp. <i>hordei</i>)	3	101	2251-2856	21-26	18 (17.82)	56.11	3.733
Septoria leaf blotch (<i>Septoria</i> sp.)	3	101	2585-3238	18.8	4 (3.96)	52	4
Loose smut (<i>Ustilago nuda</i>)	3	101	2785-3175	25-28	4 (3.96)	23.5	9.5
Head blight (<i>Fusarium</i> sp.)	3	101	2509-2593	18-25	2 (1.98)	27	3

OMP, overall mean prevalence; OMI, overall mean incidence; OMPDI, overall mean percent disease index.

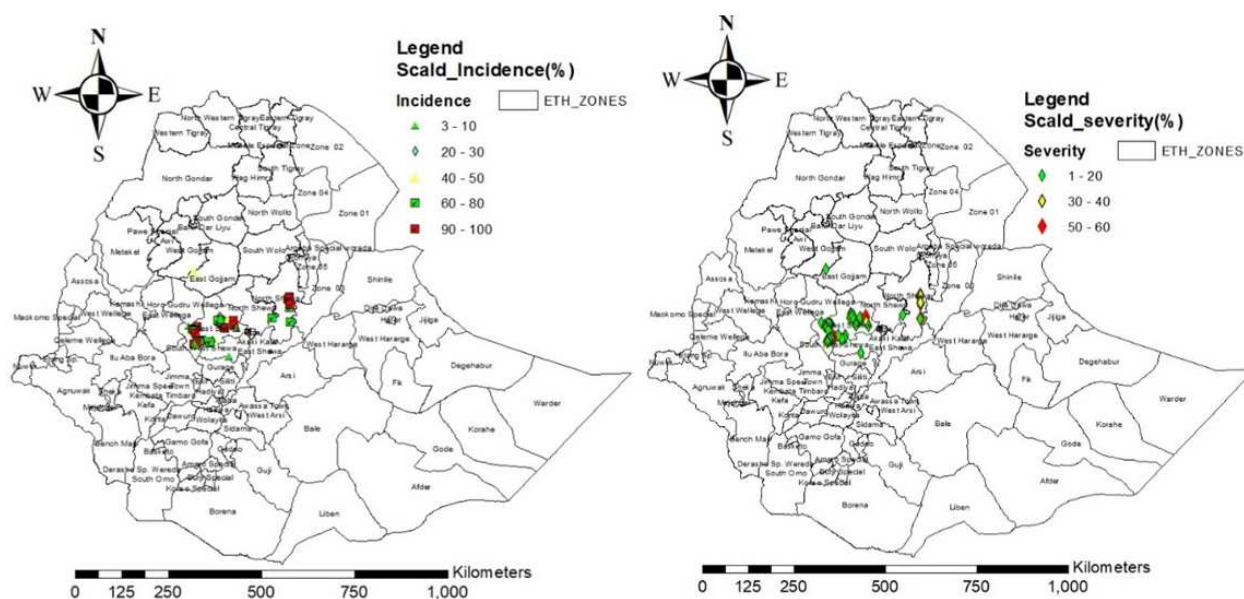
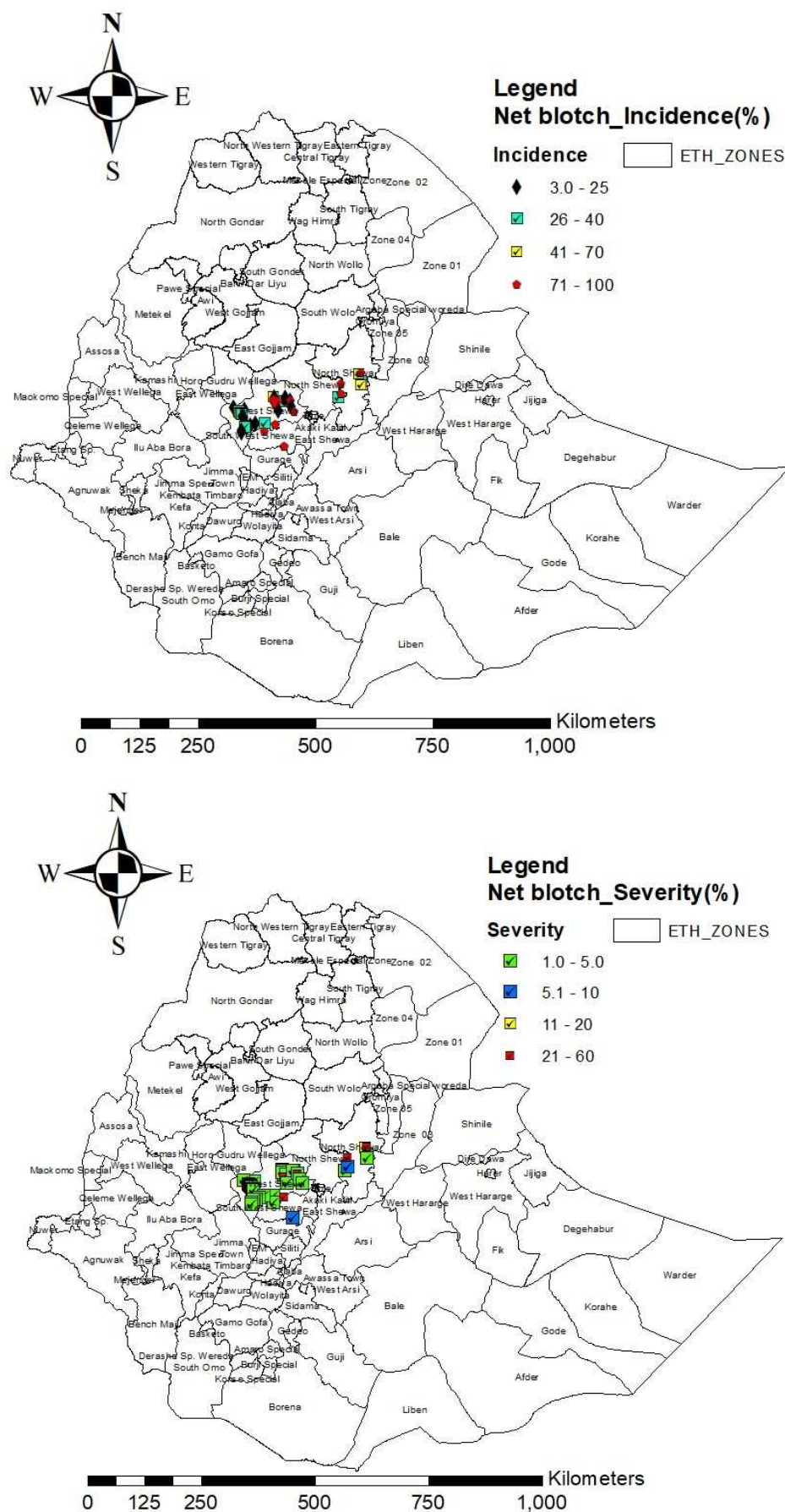


Figure 1. The distribution, percent disease incidence and severity of Scald on Barley in Ethiopia in 2017 and 2018/19 main growing season.



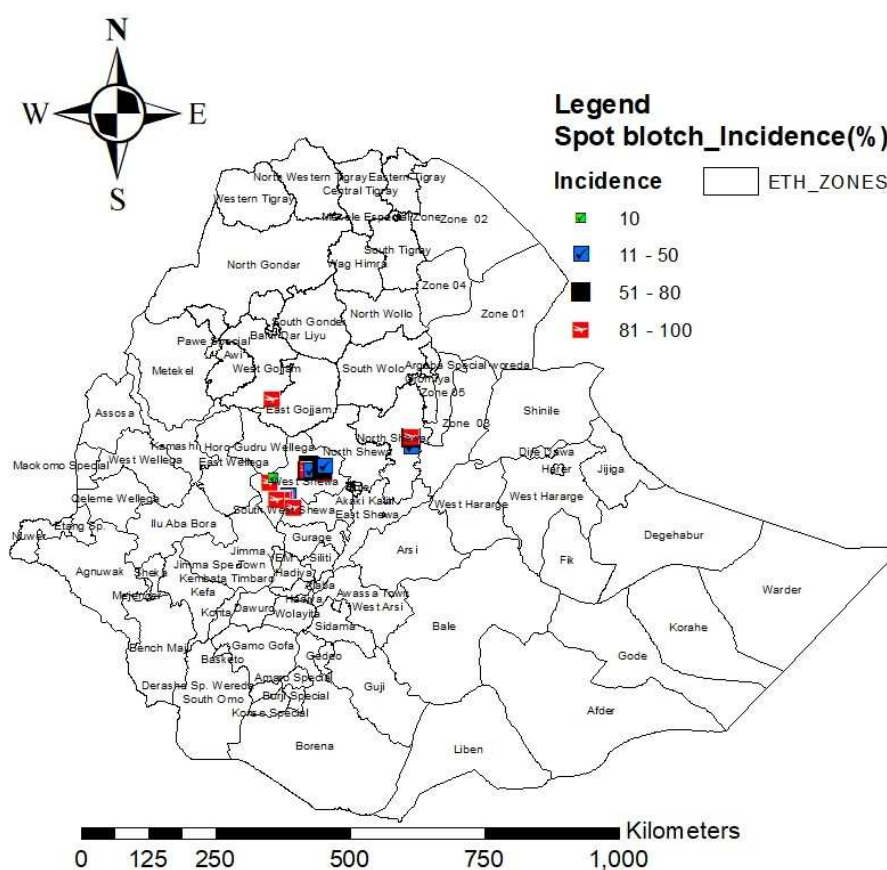


Figure 3. Disease map based on the distribution and incidence of Spot blotch on Barley in Ethiopia during 2017 and 2018/19 main growing season.

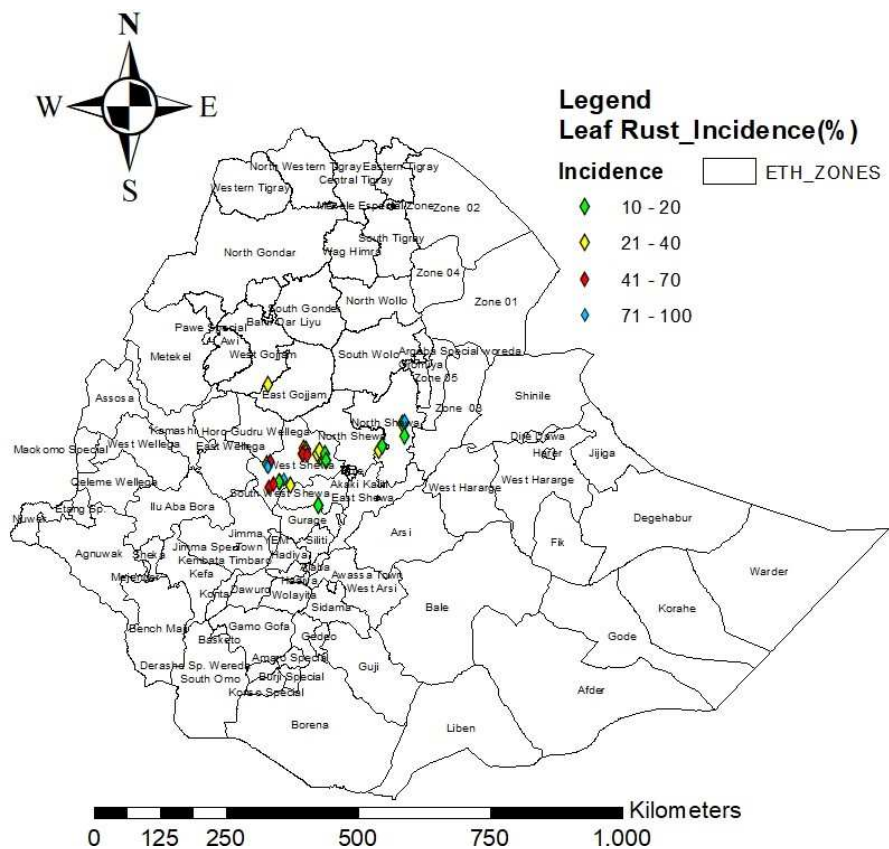


Figure 4. Disease map based on the distribution, percent disease incidence and percent severity of leaf rust on Barley in Ethiopia in 2017 and 2018/19 main growing season.

4. Conclusion

The investigation revealed the spatial distribution, intensity, importance of each major fungal disease of Barley during the main growing season. Accordingly, Spot blotch caused by *Cochliobolus sativus*, Powdery mildew caused by *Erysiphe* sp., Scald caused by *Rhynchosporium secalis*, Leaf rust caused by *Puccinia hordei*, Loose smut caused by *Ustilago nuda* and Covered smut caused by *Ustilago hordei* were relatively important and prevalent diseases at the study period. Scald percent incidence ranged from 3-100% while percent severity 1-60%. Diseases Incidence for Net blotch varied from 3 to 100% while the severity fluctuated between 1 and 60%. Study should continue towards evaluating for new sources of resistant barley genotypes at hot spot areas and/or under artificial inoculation for at least important diseases for use in improvement program and sustainable barley production in the country.

Conflict of Interests

The authors declare that they have no competing interests.

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