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Research Article

Distribution and Intensity of Wheat Stripe Rust (*Puccinia striiformis* f.sp. *tritici*) Disease in Awi Zone, North West of Ethiopia

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Abstract

Stripe or yellow rust, caused by *Pucciniastriiformiswestend* f. sp. *tritici*, is one of the most commonly occurring diseases affecting of wheat and causes a significant yield loss worldwide, including Ethiopia. The survey was conducted in 2019/2020 main cropping season in five districts of Awi Zone, Amhara region, Ethiopia, with the aim of assessing the distribution and intensity of wheat stripe rust in Awi zone. It was carried out using purposive and random sampling methods having a total of 75 farmers' fields. The results of the study revealed that, incidence and severity varied depending on agro ecologies and farmers' agronomic practices but not disease prevalence. The prevalence was 100% across zone, individual districts and Peasant associations. In contrast, incidence and severity at district level varied 71.0-97.3% and 49.0-82.3%, respectively. At Peasant associations' level, the respective incidence and severity ranged between 54%-100% and 28-97% respectively. Moreover, this study showed that different agronomic practices such as; type of preceding crop, plowing frequency, sowing method, wheat variety used, weeding system and plant growth stage did not alter the prevalence of the disease at the study area. Additionally, sowing method, plowing frequency and crop growth stage did not significantly alter incidence and severity. On the other hand, wheat variety used, previous crop, and weed density, significantly affected both disease incidence and severity. This suggests that if the environment is conducive, it may result development of disease epidemics and newly evolving races to risk of wheat to cause yield loss. To tackle this damage, intensive disease survey and surveillances needs to be conducted at untouched areas to develop management practices and develop protocols for resistance breeding and know distribution magnitude of this disease. Integration of breeding and pathology programs is a must to develop resistance variety for stripe rust and reduce yield loss.

Keywords

Prevalence, Severity, Incidence, Stripe Rust, Growth Stage

1. Introduction

Wheat (*Triticum aestivum L.*) is the world's leading cereal grain which is used by more than one third of the world population as a staple food [10]. It is produced across a wide range of agro ecological and crop management regimes It is the most important food grain source for humans supplying 40% of the world's food and 25% of calories consumed in

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developing countries [11]. The average global productivity of Wheat is around 5t/ ha with high variability among countries and regions. According to [14] East African (including Ethiopia), North African and Middle East countries consume over 150% of their own wheat production and are heavily dependent on imports to meet their food security.

Wheat is affected by many diseases. From this stripe (yellow) rust is one of the major important diseases of wheat causing severe damage to wheat production in Ethiopia [12]).Its development mainly dependent on three environmental factors: moisture, temperature and altitude. [1] reported that low temperature at night is more important for stripe rust infection than daytime temperature for germination because it gives a lot of moisture in the cold air. Worldwide epidemics of stripe rust have been previously reported, which includes Central and West Asia and East and North Africa with a high disease pressure observed in North Africa, especially Morocco [5].

The presence of a primary host (wheat or grasses) and alternative host (Berberis or Mahonia species) to complete the life cycle favors the presence of Pst. Epidemics of stripe rust were common in Ethiopia in the past and were accompanied by the emergence of virulent strains causing susceptibility to popular bread wheat cultivars such as Lakech [7] and Dashen [15].With severe infestations, the disease leads to significant reductions in yield and grain quality, up to 60% [3].

There is information gap regarding the distribution of stripe rust. Continuous survey and surveillance are required to strengthen the integrated disease management practices such as, cultural practices, fungicide and cultivars deployment. The objective of the study was conducted to assess the distribution and intensity of stripe rust in major wheat growing districts of Awi Zone, North Western Ethiopia.

2. Materials and Methods

2.1. Assessment of Stripe Rust

Wheat stripe rust disease survey was conducted during 2019/2020 main cropping season in five major wheat producing districts (Dangla, Banja, Gugusa shikudad, Ankesha Gugusa and Ayo gugusa) of Awi Zone, Amhara region Ethiopia. Three Peasant associations from each district and five farmers' fields from each Peasant association were purposively selected based on predominant wheat production status. From each district 15 farmers' field were randomly selected at an interval of 5-10km apart, making a total of 75 farmers' fields from the whole study area of Awi zone.

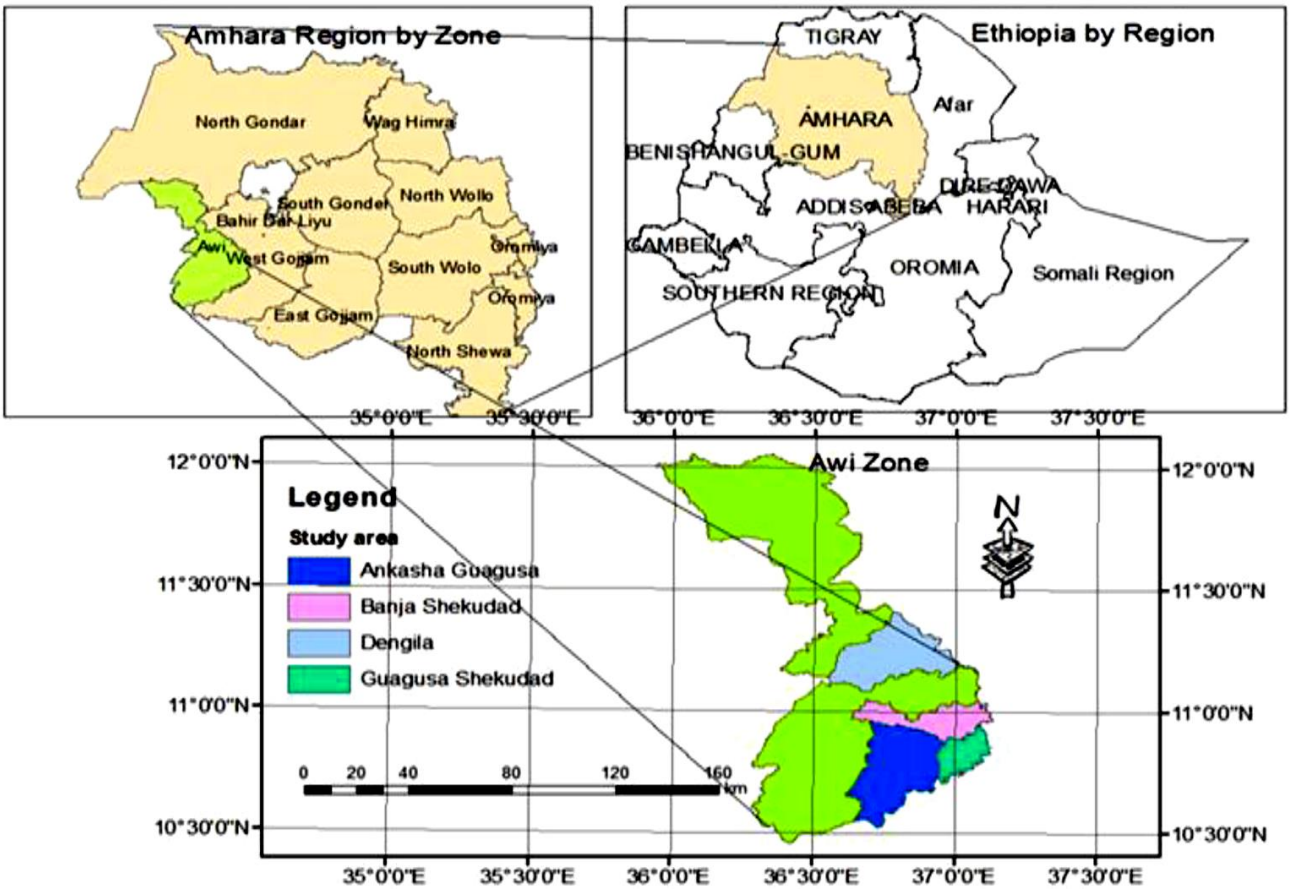

Figure 1. Geographical location of five major wheat producing districts of Awi.

2.2. Stripe Rust Disease Data Recording

The Disease incidence and severity assessments were made when the crop growth stage reached between the medium milk and early maturity stages [21]. From each sample, 5-10 (depending on the size of the field) quadrants ($1m^2$) were sampled at 15m apart from each other by making X pattern by avoiding border effect. Rust prevalence, incidence and severity data recorded from 5-10 quadrants along the two diagonals of the X axis in the field were used to calculate average values [16].

Disease prevalence of stripe rust under field condition was determined as the percentage of the plant infected and type of disease reaction or proportion or percent infected areas/ fields from the total assessed areas following the Modified Cob's Scale used by [13] was developed.

$$\text{Disease prevalence (\%)} = \frac{Number\ of\ infected\ fields}{Total\ number\ of\ fields\ assessed} \times 100$$

In each field, disease incidence was determined by counting wheat plants within the quadrate as diseased/infected or healthy/non-infected. The incidence of stripe rust was calculated using the following formula:

$$Disease\ incidence\ (\%) = \frac{Number\ of\ diseased\ plants}{Total\ number\ of\ plants\ in\ quadrant} \times 100$$

Disease severity under field condition was examined visually on the 10 randomly selected plants with in the quadrates and determined as the percentage of plant tissue affected and recorded according to the modified Cobb's scale (Figure 2). Finally, percent rust severity was calculated using the following formula:

$$\text{Disease severity (\%)} = \frac{Area\ of\ plant\ tissue\ affected}{Total\ plant\ tissue\ area} \times 100$$

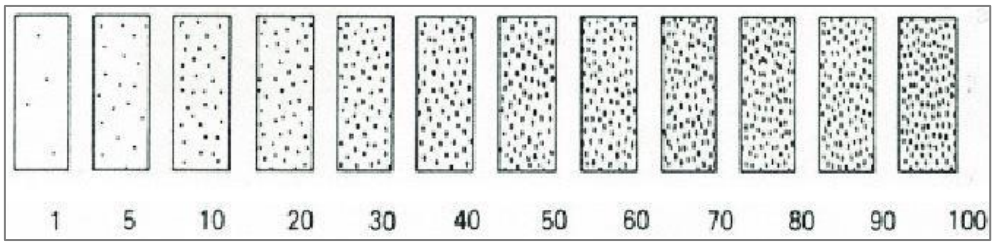

Figure 2. *Modified Cobb scale for evaluation of stripe rust severity on wheat ((Peterson et al., 1948).*

Stripe rust aggravating factors such as plowing frequency/fallow, type of the preceding crop/previous crop, weeding frequency, sowing method, wheat variety used and crop growth stages [according to the key developed by [21] were recorded.

In addition, data on geographical information (latitude, longitude and elevation) of each field was recorded using GPS (Etrex Legend PS system, Garmin).

2.3. Data Analysis

SAS version 9.4 statistical software (SAS, 2013) packages were used to run analysis of variance and mean comparisons. Field Survey data (disease incidence, severity and prevalence) was analyzed by using the nested design. The farmers' field was treated as a random effect and other factors were treated as a fixed effect. Peasant association nested under districts. GLM procedure was used to run the analysis of variance. The mean comparison was done by least significant difference (LSD). The association between independent and dependent variables was analyzed by Pearson correlation.

3. Result and Discussion

3.1. Distribution and Intensity of Wheat Stripe Rust in Awi Zone

The prevalence of stripe rust was 100% throughout the surveyed districts of Awi zone and irrespective of geographic and agronomic practices. Moreover, this study showed that different agronomic practices such as type of preceding crop, plowing frequency, sowing method, wheat variety used, weeding system and plant growth stage did not alter the prevalence of the disease in this particular study area. More importantly, the prevalence of stripe rust observed in this study was substantially higher compared to the previous reports of [2], suggesting an increasing trend of the disease in the area. This might be due to single or combined effects of several factors including the evolution of new pathogen races, long distance dispersal nature of the pathogen, and/or extensive cultivation of susceptible wheat varieties. But this doesn't mean that there was similar level of infestation

across all the surveyed districts. Rather, the degree of diseases intensity (DI and DS) across these agro ecological zones was significantly different.

Result revealed that disease incidence and severity significantly differ across districts and peasant association within districts. The mean disease incidence and severity in Awi zone was 87.3% and 63.3% respectively. The highest incidence and severity was recorded at Danigla district. On the other hand, incidence and severity was the lowest at Gugusa shikudad and Ankesha Gugusa districts (Table 1).

Altitude had an effect on the development of stripe rust disease. Similarly, [4] reported that stripe rust disease is more severe on cool climates and high land areas. Higher altitude might favor severity than lower altitude areas. When the altitude tends to increase the disease distribution and coverage was increased. This result also agreed with [19] who reported that stripe rust was more severe in altitudes higher than 2100 m.a.s.l. And also [3] reported that stripe rust disease was a major wheat disease in highlands of Ethiopia. The present study also agreed with [7] who reported that stripe rust is an important wheat disease in Ethiopian highlands between 2150 and 2850 altitudes m.a.s.l.

Table 1. *Means of wheat stripe rust incidence and severity across fifteen Peasant associations.*

Location		Altitude range	Mean Disease Parameters			
			Peasant association		District	
District	Peasant association	(m.a.s.l.)	DI (%)	DS (%)	DI (%)	DS (%)
	Bekafta	2344-2429	90ab	62bad		
Ankesha	Sostu gimjabet	2224-2263	79^{abc}	45^{cde}	85.3^{b}	55^{c}
	Tulta	2332-2394	86^{ab}	58^{bcd}		
	Chaja kibrta	2176-2210	91^{ab}	67^{cd}		
Ayogugusa	Konzena	2268-2310	89^{ab}	60^{bcd}	90.7^{ab}	61.7^{bc}
	Sostu segno	2168-2223	87^{ab}	58^{bcd}		
	Lideta	2493-2563	100^{a}	82^{ab}		
Banja	Gembeha	2574-2596	92^{ab}	70^{bcd}	92.3^{ab}	68.7^{b}
	Bata	2511-2521	85^{ab}	54^{bcde}		
	Washa	2165-2151	100^{a}	97^{a}		
Danigla	Gayta	2194-2221	98^{a}	77^{ab}	97.3^{a}	82.3^{a}
	Dimsa	2203-2252	92^{ab}	73^{abc}		
	Absila	2449-2515	93^{ab}	75^{ab}		
G/Shikudad	Gusha	2424-2524	74^{bc}	44^{de}	71.0^{c}	49.0^{c}
	Shinkurta	2456-2485	54^{c}	28^{e}		
		CV (%)	13.2	19.8	13.2	19.8
		LSD (0.05)	25.7	28	11.8	12.9

Data shown are mean values obtained from fifteen fields per district. DP=disease prevalence, DI= disease incidence; DS=disease severity CV=Coefficient of variation; LSD=List significant difference at 5%.

The observations in the present study clearly indicate that stripe rust is an economically important disease of wheat in the area. Moreover, the present finding also indicate an increasing trend of the disease, which might be associated with the evolution of new pathogen races, long distance dispersal of the pathogen, and extensive cultivation of the susceptible wheat varieties.

3.2. Relation Between Stripe Rust Intensity and Agronomic Practices

Analysis of variance result showed that plowing frequen-

cy, sowing method, and crop growth stage did not significantly alter incidence and severity of stripe rust (P≤0.05 besides, variety (P≤0.01), previous crop (P≤0.01), and weed density (P≤0.01), significantly affected both disease incidence and severity. None of the aforementioned factors had significant effect on the prevalence of stripe rust in wheat fields of the present study area (Table 2).

Different studies carried out to evaluate the effects of pre crops on stripe rust disease by using different wheat genotypes as plant protection technologies. For example, [8] reported relatively high severity (24%) when maize was used as a pre crop and (31%) whenever pea was used as a pre crop. In the current study, the highest rust severity (85%) was recorded when wheat was grown as pre crop and 47.78% was recorded when pea was grown as pre crop.

Regarding effect of wheat variety, unlike [17] who reported susceptibility of all wheat cultivars grown in surveyed areas, the degree of susceptibility varied across wheat varieties grown in the study area. The same result was reported by [6] who indicated locations and cultivars has significant effects on disease development. The present study was in line with previous reports of [20] study disease severity was stable on the resistant varieties their results indicated that stripe rust severity recorded on the resistant and moderately resistant varieties were not significant.

Moreover, wheat fields with high population density of weed were noted with high disease intensity than those with medium density of weed population. One possible explanation for such observation could be increasing of relative humidity in fields with high weed density which alter the crop microclimate favor the pathogen and weed competition for nutrients [18].

Crop growth stage did not significantly alter incidence and severity of stripe rust (P≤0.05).This result also agreed with [9] who reported that all crop growth stages susceptible to the disease. The results on the distribution and intensity of stripe rust and the role of agronomic practices on the nature of the disease described in the above paragraphs were further supported by correlation analysis of the present study. The only agronomic variables that showed significant correlation with both disease parameters (incidence and severity) were previous crop; wheat variety used and weeds density. However, sowing method, ploughing frequency and growth stage did not show significant correlation with both disease parameters (incidence and severity).

Table 2. *The effect of agronomic practices on incidence and severity.*

Agronomic variables	**Disease Parameters**	
Variety used	**Disease incidence (%)**	**Disease severity (%)**
Local	97.04[a]	81.82[a]
Kekeba	91.17[ab]	61.76[b]
Danfe	82.79[b]	56.32[b]
Digalu	80.00[b]	55.00[b]
CV (%)	14.12	26.29
LSD(0.05)	14.07	19.18
Previous crop		
Wheat	100.00[a]	85.00[a]
Finger millet	96.00[a]	77.00[a]
Maize	95.00[ab]	74.17[ab]
Barley	93.75[ab]	65.45[ab]
Teff	90.68[ab]	65.00[ab]
Fababean	86.66[ab]	62.29[ab]
Pea	76.11[b]	47.78[b]
CV (%)	14.74	29.21
LSD(0.05)	19.66	28.51
Weed status		
Bad	95.00[a]	75.00[a]
Fair	89.83[a]	66.83[a]

Agronomic variables	Disease Parameters	
Variety used	**Disease incidence (%)**	**Disease severity (%)**
Good	76.56[b]	48.43[b]
Very good	90.00[a]	48.33[b]
CV (%)	13.83	27.06
LSD(0.05)	11.84	16.96
Plowing frequency		
Five times	92.50[a]	70.00[a]
Six times	90.65[a]	64.13[a]
Seven times	85.15[a]	62.50[a]
CV (%)	15.34	30.97
LSD (0.05)	7.83	11.57
Sowing method		
Broadcasting	92.95[a]	69.31[a]
Row planting	87.07[a]	63.20[a]
CV (%)	15.37	30.83
LSD(0.05)	6.90	10.13
Crop growth stage		
Dough	93.27[a]	69.04[a]
Flowering	87.50[a]	63.40[a]
Milky	86.38[a]	50.00[a]
CV (%)	15.33	30.82
LSD(0.05)	16.57	24.4

CV (%): Coefficient of variation, LSD (0.05): List significant difference at 5% means with the same letters is not significantly different.

Table 3. *Correlation analysis describing relationships between agronomic practices and disease parameters*

Agronomic factors	Disease parameters	
	DI	**DS**
Preceding crop	-0.27**	-0.24**
plowing frequency	0.07^{ns}	0.13^{ns}
Sowing method	-0.18^{ns}	-0.37^{ns}
Wheat variety	-0.33^{**}	-0.24^{**}
Weed status (density)	0.38^{**}	0.40^{**}
Growth stage	0.13^{ns}	0.07^{ns}

Minus signs indicate negative correlations. ns, not significant. *, significant at P=0.05. **, significant at P=0.01. ***, significant at P=0.001. DI: disease incidence. DS: disease severity.

4. Conclusion

The present study clearly demonstrated that the increasing trend of stripe rust both in terms of geographical distribution as well as intensity of the disease over time (compared to previous reports). If the environment is conducive, it may result development of disease epidemics and newly evolving races to risk of wheat to cause yield loss. Rust diseases are commonly known to evolve and develop new races. In addition to this some surveyed areas farmers' even didn't aware of stripe rust as a major disease of wheat rather they consider it as a problem associated with natural hazards such as frost, drought and excess rain etc. Therefore, intensive disease survey, surveillance and information exchange among regions even at the national level should be undertaken. Capacity building and improving farmers' skills at farm level should be given to achieve effective management of stripe rust. In addition to this, in wheat production, the disease management practices and variety development efforts in the Zones should focus on stripe rust in order to sustain production and productivity of wheat cultivars.

Abbreviations

GLM	General Linear Model
m.a.s.l.	Meters above Sea Level
SAS	Statistical Software

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Author Contributions

Mintiwab Enyew is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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