
Research Article

Rate of stripe rust (*Puccinia striiformis*) on wheat in the highland and lowland area

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Abstract

Stripe (Yellow) rust caused by *Puccinia striiformis* f.sp. *tritici* (*Pst*) is a crucial wheat disease causing severe damage to cultivated susceptible wheat varieties. The wheat yellow rust assessment was conducted during the primary rainy season of 2018/19 at Ada'a, Lume, and Gimbichu using the zigzag disease assessment method. Disease data, agro-ecological data, and other essential parameters were recorded. The disease was prevalent in all districts by diverse incidence and severity ranges. This implies that yellow rust is distributed wheat disease at all surveyed potential districts. The highest yellow rust prevalence, 62.5% was recorded at Gimbichu district; conversely, the lowest prevalence 31.25% was recorded at Ada'a district. The highest severity and incidence of yellow rust 60% and 100%, respectively, was recorded at Ada'a district with susceptible reaction. In comparison, the lowest severity and incidence (30% and 5%) respectively were recorded at Lume districts with moderately sensitive responses. Many distributions and occurrences govern yellow rust. The highest incidence of yellow rust, namely 100% on land cultivated with kakaba and kubsa wheat bread varieties, occurred at the milk growth stage to the ripe stage. The local cultivar has shown the lowest incidence and severity percentage with moderately susceptible responses than improved varieties.

Introduction

Wheat is an important food crop that is cultivated in the fourth rank in Ethiopia (Food and Agriculture Organization (Food and Agriculture Organization, 2015)). Wheat is an important cereal crop and strategy for food security, which is grown in the highlands. Nowadays, wheat is also cultivated in lowlands (Beyene et al., 2016). Wheat is a food source for about 40% of the world population provides a

significant proportion of the protein and calories (Food and Agriculture Organization, 2017; Nikolai et al., 2019).

Ethiopia has experience producing bread and durum wheat in the country's highland, largely in the areas like East, Central, and northwest parts (Addis Ababa Chamber of Commerce and Sectoral Associations, 2017). The crop is grown at an altitude ranging from 1500 to 3000 (m.a.s.l) preferably 1,900 and

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2,700 m.a.s.l (Bekele et al., 2000) between 6-160N latitude and 35-420 E longitudes. The mean production of the country 3.046 t/ha (Central Statistical Agency, 2021) of the country is still low compared to the global yield, 3.65 t/ha.

The low productivity and instability of wheat productivity is caused by biotic and abiotic stresses, including water stress (Shar et al., 2021) genetic variability (Rai et al., 2021). Cereal rust fungi (*Puccinia* spp.) are among the most studied plant disease-causing agents. They affect cereals and grasses in all parts of the world, potentially causing devastating yield losses. Some of the most important cereal rust diseases are stem rust, stripe rust, leaf rust on wheat, leaf rust on rye (*P. recondita*), barley leaf rust (*P. hordei*) and crown rust on oats (*P. coronata*) (Attri & Dey, 2021; Sthapit et al., 2014). Cereal rust species can be subdivided based on their host specificity, and all cereal rusts may infect a wide variety of wild grass species. The alternate hosts of *P. graminis* include *Berberis* spp., *Mahonia* spp., *P. recondita* and *Clematis* (Jin et al., 2014; Farber & Mundt, 2017; McIntosh et al., 2018). Alternate hosts are important for epidemiology in providing build-up inoculum to rust development and in acting as a source of new pathotypes by hosting the sexual stage of the fungal life cycle. Diseases of wheat cause significant yield losses especially stem rust, leaf rust, and yellow rust (Dean et al., 2012; Grabow et al., 2016; Aktaş & Zencirci, 2016). Under very favorable conditions for the pathogen, especially at high altitudes, damages up to 100% crop loss are common (Badebo et al., 2008; Sobianti et al., 2020). In Ethiopia, frequent yellow rust epidemics have occurred in the past, accompanied by the

appearance of virulent races causing susceptibility on popular bread wheat varieties like *Lakech* (Hulluka et al., 1991) and *Dashen* (Badebo et al., 1990). In Ethiopia, several surveys and surveys have been conducted in bulk which leads to biases and missed quality. Surveying specific diseases provides complementary evidence for the reliable importance of yellow rust across all similar agro-ecology. There is a detailed information gap about the distribution of yellow rust. The purpose of the study was to gather the spread extent of yellow rust at Ada'a, Lume and Gimbichu districts of East shewa zone.

Materials and methods

Assessment of wheat stem rust in the field

The field survey for the assessment of disease intensity and distribution *Puccinia striiformis* was carried out during 2018/2019 primary cropping season at three districts of East shewa zone of Oromia region. The three districts, namely: Ada'a, Lume and Gimbichu, were selected purposively selected based suitable for wheat production and disease development. Because of the criterion, four peasant associations (PA)/kebeles were selected (Ali & Hodson, 2017) and from each PA, four fields were assessed at 5-20 km intervals from main and feeder (accessible) roadsides (Ali and Hodson, 2017). A total of 48 cultivated wheat fields were assessed; 16 fields at each three districts were assessed. During the assessment, farmer's field, Farmer's Training Center (FTC), and agricultural research stations were considered at crop growth stages between milk and maturity stages based on Zadoks cereal growth stage (0-9) key.

Table 1. Agro-ecological descriptions of survey study areas

Agro-ecology		Districts		
		Ada'a	Lume	Gimbichu
Latitude (N)		44''	8°58''	8°12''
Longitude (E)		38°57'	39°06'	39°17''
Altitude (m.a.s.l)		1950	2450	1900
Temperature	Minimum	8°C	9°C	9.2 °C
	maximum	28°C	29°C	29.3 °C
	Average	19°C	17°C	19 °C
RF (mm)		851	1200	951

Source: (Addis et al., 2001) (Gimbichu district)

The assessment was made at five points along the two diagonal zigzag patterns of the field using 1m x 1m (1m²) quadrat and used to

calculate average values. The yellow rust prevalence was estimated by using the formula:

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

Moreover, disease incidence was estimated by the formula:

$$\text{Yellow rust incidence} = \frac{\text{Number of Diseased plants}}{\text{Total proportional number of plants in the quadrat}} * 100$$

Disease observations were recorded in response and the severity of stripe rust was recorded (Table 2) according to (Loegering, 1959). Yellow rust severity (%) was recorded from the

fields at all growth stages. Estimates of severity were measured according to Modified Cobb Scale. The severity was recorded as the percent of rust infection on the plants (Figure 1).

Table 2. The observation on response of stripe rust

Reaction	Observation	Response value
No Disease	O	0.0
Resistant	R	0.2
Resistant to Moderately Resistant	R-MR	0.3
Moderately Resistance	MR	0.4
Moderately Resistant to Moderately Susceptible	MR-MS	0.6
Moderately Susceptible	MS	0.8
Moderately Susceptible to Susceptible	MS-S	0.9
Susceptible	S	1

In each field, wheat plants within the quadrat were counted and recorded as infected and non-infected, and disease incidence was

calculated. The incidence of yellow rust was calculated as follows.

$$\text{Yellow rust severity} = \frac{\text{Number of Diseased plants}}{\text{Total proportional number of plants in the quadrat}} * 100$$

Severity was recorded by visual observation; below 5% severity intervals were as trace (T) to 1.

Readings of severity and reaction were recorded as follow:

TR : Trace severity of resistant type infection.

10MR : 10% severity of a moderately resistant type infection.

30MS : 30% severity of a Moderately Susceptible type infection.

50S : 50% severity of a susceptible type infection.

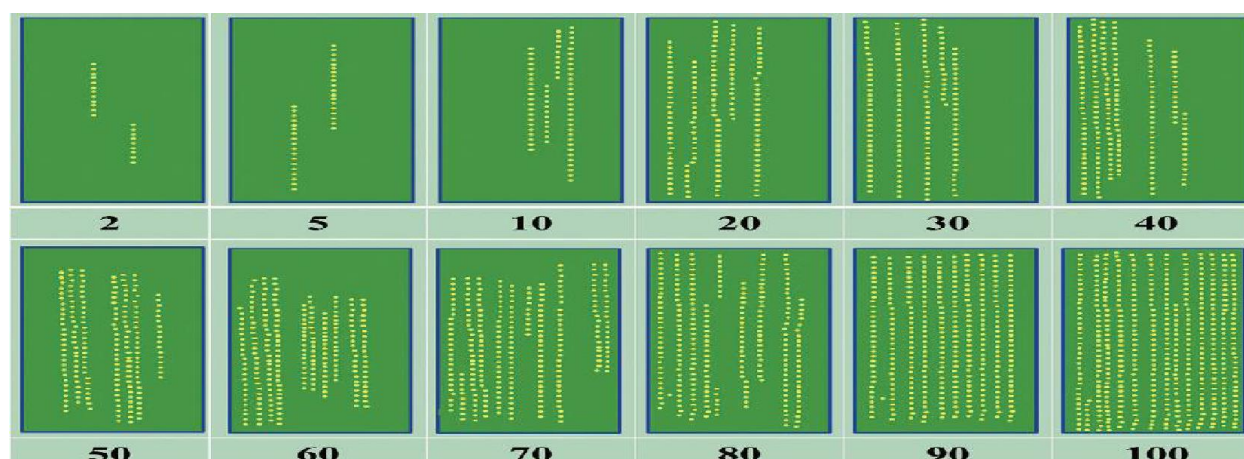


Figure 1. Yellow rust severity score scale

Source: Loegering (1959)

In addition to the disease parameters, other agronomic and ecological data of the field were recorded. Other important contributing factors of agro-ecological data such as: latitude, longitude, and elevation (m.a.s.l) of each field were recorded using Garmin 600 model GPS (Table 1).

Results and discussion

Prevalence of yellow rust at East shewa zone

The disease was detected in all surveyed districts with a diverse prevalence percentage. During the assessment highest yellow rust prevalence, 62.5% was confirmed at Gimbichu district, but; the lowest stripe rust prevalence 31.25%, was at Ada'a district. The elevation of

Gimbichu district is grouped as a high land area. In agreement with Badebo et al. (2008) and Ashagre (2021) reported that yellow rust is more severe by the low temperature at high altitudes. Stripe rust (*Puccinia striiformis*) disease was reported as principally a disease of wheat grown in cooler climate conditions (2 to 15°C); generally associated with higher elevations, northern latitudes, or cooler conditions. The low yellow rust prevalence percentage at Ada'a is due to be categorized under lowland agroecology. The response of the wheat cultivated infection is shown as from zero to susceptible reactions. Based on all assessment criteria, yellow rust is becoming important in all districts as indicated below (Table 3).

Table 3. Prevalence of yellow rust at assessed districts with varying altitude

Districts	Prevalence	Altitude (m.a.s.l)	Incidence (%)	Severity (%)	Response
Ada'a	31.25 %	1879-1957	100	60%	Zero-S
Lume	56.25%	1811-2003	30	5%	MS
Gimbichu	62.5%	2297-2443	60	5%	MS

Among a total of 48 assessed fields, yellow rust was detected only at 24 fields. At Ada'a districts, five fields out of 16 fields were infected by 100% and 60% S of incidence, severity and response on cultivated wheat (Table 4). Ada'a district is located at mid-altitude. Whereas, at Lume district, only nine fields were detected with low infection by 30% and 5% incidence and severity with a moderately susceptible

response. Even more, fields are infected with low yellow incidence, and severity is recorded. This moderately susceptible doesn't indicate that cultivated wheat is not tolerant for the disease because a Lume district is known not important for yellow rust development. Lume district is categorized under low altitude agroecology. Lume district is not important for yellow rust occurrences.

Table 4. Number of infected fields among assessed farms

Districts	Farms detected		Incidence %	Severity %	Response
	Total	Infected			
Ada'a	16	5	100%	60 %	S
Lume	16	9	30%	5%	T
Gimbichu	16	10	60%	5%	T

At Kality and Gole PA's of Ada'a and Lume districts were not infected during the assessment, fields of peasant associations were infected by yellow rust (stripe rust). Among assessed farms, higher yellow rust incidence 100% and 60-80% were observed at Denkaka and Tadecha PA's of Ada'a district (Table 5). When comparing the districts by Peasant associations; The highest incidence and severity of

yellow rust at Lume district was 15% and 5% at Golba Gode, and Tullu re'ee and dhaka boora each, respectively (Table 5). Regarding severity, the lowest yellow rust severity zero (0) were noted at Ada'a district of Kality PA's and Gole of Gimbichu district. But during the survey season, the wheat crop is severely infected by stem rust at all assessed locations.

Table 5. Variation of yellow rust in the peasant associations/kebeles in each district

Districts	PA	Altitude	Incidence	Severity	Response
Ada'a	Kality	1879-1931	0	0	0
	Ganda Gorba	1915-1957	5%	5%	MS
	Tadechaa	1905-1932	60-80%	40%	MS
	Denkaka	1874-1928	100%	60%	S
Lume	Golba Godde	1849-1914	0-15%	5%	T
	Tullu re'ee	1960-2003	0-5%	0	MS
	dhaka boora	2029-2094	0-5%	0	T
	Sharraa dibandiba	1811-1978	30%	5%	MS
Gimbichu	Girmi	2297-2328	0-50%	5%	MS
	Lemlem chefe	2307-2322	5-60%	5%	MS
	Habru seftu	2421-2438	0-25%	5%	MS
	Gole	2438-2443	0	0	0

The growth stage influences disease infection. The maturation phase is the stage that is more resistant to disease. In addition, yellow rust is also affected by wheat varieties. The highest yellow rust incidence ranges from 80% recorded in the milking wheat growth stage (Ashagre, 2021). As a result of the assessment, the highest severity was 100% S on the dough stage at Ada'a district (Table 7). While the lowest incidence, zero, was recorded on the Booting and Maturity stage. This outcome shows that wheat growth and maturity stage have a

direct correlation with incidence and severity ranging from zero (0) to complete infection of incidence and susceptible reaction. In addition, cultivated wheat varieties also give a chance for the occurrence of yellow rust. The wheat maturity stage has its own effect on yellow rust occurrence (Table 6). Early appearance causes a marked impact on the growth and vigor of the wheat, the growth, growth of leaves being retarded, and the final length and breadth significantly reduced (Doodson et al., 1964).

Table 6. Incidence and severity of stripe rust as affected by maturity stage

Districts	Maturity stage	Incidence	Severity	Response
Ada'a	Booting	0	0	0
	Milking	0-80%	0-40%	Zero-S
	Dough	0-70%	0-100%	Zero-S
	Mature	0	0	0
Lume	Booting	0	0	0
	Milking	0-20	0-5%	MS
	Dough	0-40	0-30%	MS
	Mature	0	0	0
Gimbichu	Booting	0	0	0
	Milking	0-60%	0-5%	MS
	Dough	0-50%	0-5%	MS
	Mature	0	0	0

A yellow rust occurrence is also affected by wheat variety and growth stage. The highest yellow rust incidence ranges 0-100% found at fields cultivated with bread wheat (Ashagre, 2021). As a result of the study, a higher incidence of 100% was obtained on Kubsa bread wheat variety at the growth stage of Milk to the

matured stage (Table 7). The local cultivar has shown the lowest incidence and severity percentage with moderately susceptible responses than improved varieties. Fields cultivated with Mangudo had revealed 80% and 5 MS of incidence and severity of yellow rust, respectively.

Table 7. Incidence and severity of stripe rust on variety

Variety	Incidence	Severity	Response
Mangudo	0-60%	5%	MS
Ude	0	0	0
Local Cultivars	0-25%	0-5%	MS
Kubsa	0-100%	60S	S
Kakaba	0-40%	0-15%	MS

Conclusion

Yellow rust has a widespread range, same as other rusts. This may result in disease epidemics and newly evolving races to risk wheat production to cause yield loss. Rust disease is commonly known to grow and develop new races. Disease survey and surveillance needs to be conducted in untouched areas to understand the distribution magnitude of this disease. Surveys and surveillances at varying agro-ecology and wheat varieties cultivated need to be conducted. Integration of breeding and pathology programs is necessary to develop resistance variety for yellow rust and reduce yield loss. Using local cultivars as a source for genetic improvement is mandatory for sustainable production for food security.

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Author's declaration and contribution

Authors declare that there is no conflict of interest. AAZ: Designed the experiment procedure, collected the data, performed statistical analysis of data and arranged the first draft of this study. JHP (Associate professor of Agronomy): Assisted in arranging the first draft of this article, revised the first draft minutely and elaborated the final manuscript for publication.

References

- Addis Ababa Chamber of Commerce and Sectoral Associations (AACCSA). (2017). *Value chain study on wheat industry in Ethiopia by afro-universal consultant and general trading P.L.C. final report Addis Ababa, January, 2017*.
- Addis, T., Teklu, T., Mwangi, W., & Verkuijl, H. (2001). *Gender differentials in agricultural production and decision-making among smallholders in Ada, Lume, and Gimbichu woredas of the central highlands of Ethiopia*. International Maize and Wheat Improvement Center (CIMMYT) and Ethiopian Agricultural Research Organization (EARO).
- Aktaş, H., & Zencirci, N. (2016). Stripe rust partial resistance increases spring bread wheat yield in South-eastern Anatolia, Turkey. *Journal of Phytopathology*, 164(11–12), 1085–1096. [CrossRef](#)
- Ali, S., & Hodson, D. (2017). Wheat rust surveillance: field disease scoring and sample collection for phenotyping and molecular genotyping. In S. Periyannan (Eds.), *Wheat rust diseases* (pp. 3–11). Humana Press. [CrossRef](#)
- Ashagre, A. (2021). Prevalence of Yellow Rust at Minjar , Basonawarena and Moretenajihur District of North Shewa Zone , Ethiopia. *American Journal of Bioscience and Bioengineering*, 9(6), 151–155. [CrossRef](#)
- Attri, H., & Dey, T. (2021). Screening of stripe rust resistance in bread wheat (*T. aestivum* L.) genotypes. *International Journal of Current Microbiology and Applied Sciences*, 10(01), 1236–1244. [CrossRef](#)
- Badebo, A., Bekele, E., Bekele, B., Hunde, B., Degefu, M., & Tekalign, A. (2008). Review of two decades of research on diseases of small cereal crops in Ethiopia. *Proceedings of the 14th Annual Conference of the Plant Protection Society of Ethiopia (PPSE)*.
- Badebo, Ayele, Stubbs, R. W., van Ginkel, M., & Gebeyehu, G. (1990). Identification of resistance genes to *Puccinia striiformis* in seedlings of Ethiopian and CIMMYT common wheat varieties and lines. *Netherlands Journal of Plant Pathology*, 96, 199–210.
- Bekele, H. K., Varkuijl, H., Mwangi, W., & Tanner, D. G. (2000). *Adaptation of improved wheat technologies in Adaba and Dodola woredas of the Bale highlands, Ethiopia*. International Maize and Wheat Improvement Centre (CIMMYT) and Ethiopian Agricultural Research Organization (EARO).
- Beyene, Y., Semagn, K., Crossa, J., Mugo, S., Atlin, G. N., Tarekegne, A., Meisel, B., Sehabiague, P., Vivek, B. S., Oikeh, S., & Alvarado, G. (2016). Improving maize grain yield under drought stress and non-stress environments in sub-Saharan Africa using markerassisted recurrent selection. *Crop Science*, 56(1), 344–353.
- Central Statistical Agency (CSA). (2021). *Agricultural Sample Survey, 2020/21. First report on area and production of major crops 1*.
- Dean, R., Van Kan, J. A., Pretorius, Z. A., Hammond, Kosack, K. E., Di Pietro, A., Spanu, P. D., Rudd, J. J., Dickman, M., Kahmann, R., Ellis, J., & Foster, G. D. (2012). The Top 10 fungal pathogens in molecular plant pathology. *Molecular Plant Pathology*, 13(4), 414–430.
- Doodson, J. K., Manners, J. G., & Myers, A. (1964). Some effects of yellow rust (*Puccinia striiformis*) on the growth and yield of a spring wheat. *Annals of Botany*, 28(3), 459–472.
- Farber, D. H., & Mundt, C. C. (2017). Effect of plant age and leaf position on susceptibility to wheat stripe rust. *Phytopathology*, 107(4), 412–417. [CrossRef](#)
- Food and Agriculture Organization (FAO). (2015). *Food balance sheets*. FAOSTAT.
- Food and Agriculture Organization (FAO). (2021, September 26). Crop prospects and food situation: Quarterly global report. FAO. [Direct Link](#).
- Food and Agriculture Organization (FAO). (2021, September 25). Save food: Global initiative on food loss and waste reduction, key findings. FAO. [Direct Link](#).
- Grabow, B. S., Shah, D. A., & DeWolf, E. D. (2016). Environmental conditions associated with stripe rust in Kansas winter wheat. *Plant Disease*, 100(11), 2306–2312. [CrossRef](#)
- Hulluka, M., Woldeab, G., Andrew, Y., Desta, R., & Badebo, A. (1991). *Wheat pathology research in Ethiopia pp. 173-217. In: Wheat research in Ethiopia: A historical perspective. Gebre-Mariam J, Tanner DG and Huluka M (Eds). Addis Ababa, IAR/CIMMYT*.
- Jin, Y., Rouse, M., & Groth, J. (2014). Population diversity of *Puccinia graminis* is sustained through sexual cycle on alternate hosts. *Journal of Integrative Agriculture*, 13(2), 262–264.
- Loegering, W. Q. (1959). *Methods for recording cereal rust data in international spring wheat rust nursery (IRN)*. United States Department of Agriculture.
- McIntosh, R., Mu, J., Han, D., & Kang, Z. (2018). Wheat stripe rust resistance gene Yr24/Yr26: A

- retrospective review. *The Crop Journal*, 6(4), 321–329. [CrossRef](#)
- Nikolai, B., Kishchenko, O., Eliby, S., Schramm, C., Anderson, P., Jatayev, S., Kurishbayev, A., & Shavrukov, Y. (2019). Genetic modification for wheat improvement: from transgenesis to genome editing. *BioMed Research International*, 2019, 1–18. [CrossRef](#)
- Rai, R., Khanal, P., Chaudhary, P., & Dhital, R. (2021). Genetic variability, heritability and genetic advance for growth, yield and yield related traits in maize genotypes. *Journal of Agriculture and Applied Biology*, 2(2), 96–104. [CrossRef](#)
- Shar, P. A., Shar, A. H., Memon, S., Soomro, A. A., Naich, S. A., Rind, N. A., Laghari, A., Rind, K. H., Meghwar, P., & Otho, S. A. (2021). Morpho-physiological responses in wheat (*Triticum aestivum* L) influenced by normal and water stress conditions. *Journal of Agriculture and Applied Biology*, 2(1), 1–10. [CrossRef](#)
- Sobianti, S., Soesanto, L., & Hadi, S. (2020). Inventory of seed-transmitted pathogenic fungi in five rice varieties. *Agro Bali : Agricultural Journal*, 3(1), 1–15. [CrossRef](#)
- Sthapit, J., Newcomb, M., Bonman, J. M., Chen, X., & See, D. R. (2014). Genetic diversity for stripe rust resistance in wheat landraces and identification of accessions with resistance to stem rust and stripe rust. *Crop Science*, 54(5), 2131–2139. [CrossRef](#)