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Prevalence of Yellow Rust at Minjar, Basonawarena and Moretenajihur District of North Shewa Zone, Ethiopia

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Abstract: Stripe (Yellow) rust caused by *Puccinia striiformis* f.sp. *tritici* (*Pst*) is important wheat diseases causing serious damage on cultivated wheat variety. The wheat yellow rust assessment was conducted in the main rainy season of 2018/19 at Minjar, Basonawarena and Moretnajihur using "Z" method of diseases assessment. Disease and agro-eological data were recorded. The disease was prevalent at all districts by varying incidence and severity ranges. The highest Yr prevalence 100% was recorded at Moretenajihur districts: conversely; the lowest prevalence percentage 16.67% was at Minjar district. The highest severity and incidence of yellow rust 40-100% and 10-40%, respectively was recorded at Moretenajihur with MS to S reaction; while the lowest severity and incidence (0-15% and 0-5%) respectively was recorded at Minjar with reaction of MS. Factors such as wheat variety, growth stage and agro-ecological variations have contributions for the distributions and occurrence of yellow rust. Highest yellow rust incidence ranges 100% S on field cultivated with bread wheat on variety kakaba and Kubsa at growth stage of Milk to matured stage. Local cultivar has shown lowest incidence and severity percentage with moderately susceptible responses than improved varieties.

Keywords: Prevalence, Severity, Incidence, Districts and Yellow Rust

1. Introduction

Wheat is a strategically important crop for food security in Ethiopia which is widely cultivated at high altitude ranging between 1900-2700 m.a.s.l. [9]. It is ranked fourth in area coverage and total production after teff, maize and sorgum [6]. In rapidly urbanizing Sub-Saharan Africa, wheat consumption is grown by the demand increased in Ethiopia particularly due to the establishment food processing industries [17]. Wheat is affected by many diseases. Among this stripe (Yellow) rust caused by *Puccinia striiformis* f.sp. *tritici (Pst)* is one of the most important diseases of wheat causing serious damage to wheat production in the highlands of Ethiopia [21]. Stripe rust disease development is mainly dependent on three environmental factors: moisture, temperature and altitude. Ashgre [2] Confirmed that low night temperature is more important for yellow rust infection than day-time temperature for germination it provides enough moisture in cold air. Over the last decade outbreaks of yellow rust epidemics have been reported worldwide, including Central and West Asia and East and North Africa with a high disease pressure was observed in 2009 and onward in North Africa, particularly in Morocco [8]. The presence of primary (wheat or grasses) and alternate (Berberis or Mahonia species) host plants to complete its life cycle favors for the presence of *Pst*. The sexual stage on Berberis spp. and Mahonia spp. has only been described recently [12, 20]. Mutation, somatic recombination, parasexuality, selection and probably sexual recombination are considered to be the mechanisms that drive pathogen variability [7]. In Ethiopia, frequent yellow rust epidemics have occurred in the past accompanied by appearance of virulent races causing susceptibility on popular bread wheat verities like Lakech [10] and Dashen [4, 18]. Under severe infection the disease causes substantial yield and grain quality reduction under severe infestations up to 60% is observed [3]. There is information gap about the distribution of yellow rust. To

strengthen the integrated disease management practices such as, cultural practices, fungicide and cultivars deployment it needs continuous survey and surveillance has been conducted to detect the presence of yellow rust (*Puccinia striliformis*). The objective of the study was conducted to detect the presence of yellow rust at selected districts of north shewa zone that are Mimjar, Basonawarena and Moretnajihur.

2. Materials and Method

2.1. Assessment of Yellow Rust

The field survey, for the assessment of disease intensity and distribution *Puccinia striliformis* f.sp. *tritici* races was carried out during 2018/19 cropping season at North shewa zone which is purposely selected based on wheat growing potential areas and suitability for the disease development. Considering the aforementioned criteria, three districts were selected. A total of 42 fields were assessed; 10, 16 and 16 fields at Basonawarena and Moretenajihur districts were assessed. From each district, two to four peasant associations (PA) [1] were selected and from each PA, four farms were assessed at 5-20 km interval following main and feeder (accessible) roadsides. In addition to farmer's field; Farmer's Training Center (FTC) and agricultural research stations were included. The survey was conducted between milk and maturity stages based on Zadoks cereal growth stage (0-9) key.

Table 1. *Agro-ecological descriptions of survey study areas.*

Agro-ecological factors		Districts		
		Moretenajihur	Basonawerana	Minjar
Latitude (N)		9°36'	10° 41′	8° 45"
Longitude (E)		39°38`	39° 47′	39° 15'
Altitude (m.a.s.l)		2828	2828	2120
Temperature (°C)	Min.	6.1°C	13.5°C	13°C
	Max.	24°C	21.5°C	29°C
	Av.	15.15°C	18°C	21°C
Rain Fall (mm)		890	1000	854

Source: Befekadu [5] (Minjar district);

2.2. Yellow Rust Disease Data Recording and Analysis

Moreover, disease prevalence was estimated by the formula:

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

Disease observations were recorded on response and severity of stripe rust was recorded according to [14] and [11]. Yellow rust severity (%) was recorded from the fields at all growth stage [13]. Estimates of severity were measured according to Modified Cobb Scale [15]. The severity was recorded as 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

Assessment of stem rust incidence and severity was made at five points of zigzag sampling method of the field using 1m x 1m ($1m^2$) quadrant and used to calculate average values. In each field, wheat plants within the quadrate were counted and recorded as diseased/infected and healthy/non-infected and disease incidence was calculated. The incidence yellow rust was calculated using the number of infected plants and expressed as a percentage of the total number of plants assessed.

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

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.

In addition to the disease parameters, other agronomic and ecological data of the field were recorded. Average crop growth stage was recorded according to Zadoks cereal growth stage (0-9) key. Data on ecological data such as: latitude, longitude and elevation of each field were recorded using Garmin 600 model GPS.

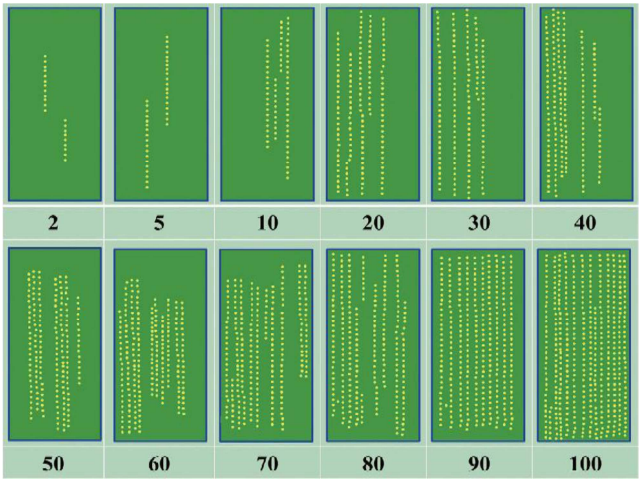

Figure 1. *Yellow rust severity score scale: Source: [14] and [11].*

3. Result and Discussion

3.1. Prevalence Yellow Rust within Districts

Yellow rust was spread at all assessed districts with different prevalence percentage. During the assessment high yellow rust prevalence percentage 100% was recorded at Moretenajihur districts: conversely; the low yellow rust mean prevalence percentage 16.67% was recorded at Minjar district. This implies that yellow rust is distributed wheat disease at all surveyed potential districts. At Minjar district zero (0) incidence and severity value was recorded; this is due to high temperature and low altitude. [2] Agreed that yellow rust is favored by low temperature than high temperature. Stripe rust (*Puccinia striliformis*) 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 [19]. The low yellow rust prevalence percentage at Minjar district is due to the agro-ecology of the location since Minjar districts is categorized under lowland agro ecology. This yellow occurrence may favor for the epidemics of yellow rust if it get into more suitable environment. For this issue wheat improving programs need to focus on to developing resistant variety to reduce the damage. Based on all assessment criteria; yellow rust is becoming important at all districts as indicated below (Table 3).

Table 3. *Prevalence of yellow rust at assessed districts.*

Districts	Field assessed	Yellow rust Infected fields	Yellow rust free fields	Prevalence %
Minjar	10	2	8	16.67%
Basonawarena	16	15	1	93.75%
Moretenajihur	16	16	0	100%

3.2. Incidence and Severity Within the Districts

Disease incidence and severities are major measurement character of disease assessment. Yellow rust distribution was distributed at all assessed districts with different value. Broadest yellow rust incidence range was recorded up to 100% S at Basonawarena district with moderately susceptible to susceptible responses; while the lowest was 15% was recorded at Minjar with moderate susceptible (Table 4). Highly sever incidence 40-100% was recorded at Basonawarena district with sever susceptible responses. Manandhar *et al*. (1989) described; yellow rust is the major problem to the wheat cultivated in highlands causing 15-20% yield losses. Regarding severity; higher severity 10-40% was recorded at Moretenajihur district by moderately susceptible (MS) to susceptible (S), While; the lowest severity 0-5% was recorded at Minjar district (Table 4). Among 10 fields assessed fields only on 2 fields yellow rust infection were recorded. Yellow rust caused up to 60% under severs epidemics at Hadiya zone [2].

Table 4. *Yellow rust incidence and severity percentage in the districts.*

Districts	Incidence %	Severity %	Wheat response
Minjar	0-15%	0-5%	Moderately Susceptible
Basonawarena	0-100%	0-40%	Free/zero to susceptible
Moretenajihur	40-100%	10-40%	Moderately Susceptible to susceptible

3.3. Yellow Rust Incidence and Severity in Peasant Associations (PA)

Except at Memeherhager and Samasenbet PA's at Minjar districts were not infected during the assessment fields of peasant associations were infected by yellow rust (stripe rust). Among assessed farms at Minjar districts; yellow rust infection were observed only at shewa genet (PA) by 0-15% of incidence was recorded. While comparing peasant associations at Basonawarena district; highest incidence percentage 10-100% was recorded at Bakelo peasant associations; conversely narrowest incidence 0-40% was at Angolella peasant associations. PA's at Moretenajihur; widest stripe rust incidences 40-100% were recorded at Gerba PA; while the narrowest stripe rust incidences 80-100% was recorded at Denato peasant associations. Regarding severity; lowest yellow rust severity zero (0) were noted at Minjar district of Memherhager and samasenbet. But during the survey season wheat crop is severely infected by stem rust at all assessed locations.

Table 5. Yellow rust incidence and severity in peasant associations.

Districts	Peasant associations (PA)	Incidence %	Severity %	Wheat response
Minjar	Shewagenet	0-15%	0-5%	MS
	Memhirhager	0	0	0
	Samasenbet	0	0	0
Basonawarena	Angolella	0-40%	0-10%	MS
	Bakelo	10-100%	10-40%	MS-S
	Sarya	10-40%	5-25%	MS
	Atakilt	40-80%	10-40%	MS
Moretenajihur	Bollo	40-70%	10-40%	MS-S
	Gerba	40-100%	15-35%	MS-S
	Denaton	80-100%	15-40%	MS-S
	Mangudo	40-80%	15-30%	MS-S

3.4. Incidence and Severity of Yr at Varying Agro-ecology

Agro-ecological variations have contributions for the distributions and epidemic occurrence of yellow rust. During the survey the area were categorized under high altitude. The disease can be found in all highland and temperate areas where cereals are grown [16]. Stripe rust or yellow rust 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 [19]. The disease can be found in all highland and temperate areas where cereals are grown [16].

Table 6. Comparison of peasant associations by severity and incidence of yellow rust.

Districts	Altitude (m.a.s.l)	Maturity stage	Incidence%	Severity%
Minjar	1802-2147	Dough to matured	0-15%	0-5%
Basonawarena	2651-2867	Milk to dough stage	0-100%	0-40%
Moretenajihur	2651-2669	Milk to dough stage	40-100%	10-405

3.5. Incidence and Severity of Yr as Affected by Varieties and Growth Stage

Yellow rust occurrence is also affected by wheat variety and growth stage. Highest yellow rust incidence ranges 0-100% found at field cultivated with bread wheat [2]. As a result of the study; higher incidence 0-100%S was obtained on Kakaba and Kubsa bread wheat variety at growth stage of Milk to matured stage (Table 7). Local cultivar has shown lowest incidence and severity percentage with moderately susceptible responses than improved varieties.

Table 7. Incidence and severity of stripe rust by varieties and maturity stage.

No.	Assessed varieties		Maturity stage	Incidence%	Severity%	Wheat response
	Variety	No.				
1	Kubsa	18	Milk-Matured	10-100%	5-40%	MS-S
2	Mangudo	10	Dough-Matured	0-80%	0-40%	MS-S
3	kakaba	12	Milk-Matured	0-100%	0-40%	MS-S
4	Local cultivar	2	Dough	5 and 40%	5 and 10%	MS

Fields cultivated with Mangudo had revealed 0-80% and 0-40% of incidence and severity of yellow rust, respectively. This result shows that wheat growth and maturity stage have direct correlation with incidence and severity ranging from zero (0) to complete infection. In addition; improved wheat variety gives a chance for the occurrence of yellow rust.

4. Conclusion

Yellow rust has wide range of spread across all assessed agro ecologies. If conducive environment available, it may result development of disease epidemics and newly evolving races to risk of wheat to cause yield loss. Rust disease is commonly known to evolve and develop new races. To tackle this damage; disease survey and surveillances needs to be conducted at untouched areas to develop protocol for resistance breeding and know distribution magnitude of this disease. Integration of breeding and pathology programs is a must 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.

Conflict of Interest

The author declared no competing interests.

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