

Full Length Research Paper

Distribution and seasonal variation on occurrence of wheat stem rust in Tigray, Ethiopia

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Abstract

Stem rust is the major diseases of wheat in Ethiopia, causing significant losses to yield and quality in years with suitable conditions. A survey of wheat rusts were carried out in South Tigray for four consecutive years (2010-2013) and rust trap nursery trial in 2014 to monitor the status and importance of stem rust. Sixty-six, 52, 61, and 70 wheat fields were examined, of which, 33.3%, 9.6%, 19.2% and 10% were infected with stem rust from 2010-2013, respectively. The maximum incidence and severity of stem rust was scored in Raya-Azebo and Raya-Azebo districts. Most of the high yielding commercial wheat cultivars (58.3%) were susceptible to stem rust, putting a significant wheat proportion at risk. Similarly, most of the stem rust assistance genes were affected by the pathogen population at different intensity level. Hence, durable rust resistance may be achieved by pyramiding, that is, accumulating several effective resistance genes in one cultivar helped to extent the longevity of resistance against the disease.

Keywords: Stem rust, wheat, seasonal variation, distribution

INTRODUCTION

Stem rust also called black rust of wheat, caused by fungus *Puccinia graminis* Pers. f. sp. *tritici* Eriks. & E. Henn., historically is known to cause severe devastation periodically and was most feared disease in various countries in all continents where wheat is grown^{12, 13, and 18}. The fear from stem rust is understandable because an apparently healthy looking crop of a susceptible cultivar about three weeks prior to harvest could reduce to a black tangle of broken stems and shriveled grains by harvest. There are several major wheat production areas worldwide in which stem rust can cause severe losses due to environments that are conducive to disease development.

Stem rust is also a major disease of wheat in Ethiopia, and it is widespread in the wheat growing regions, particularly in Central, South-East and North-West Ethiopia^{2 and 4}. Epidemics of stem rust have been occurred in Ethiopia at different times starting from the

first recognized since 1930s^{5, 7, 13, and 17}. The yield losses due to stem rust have been reported to be in the range of 61-100% depending on the susceptibility of the variety and environmental conditions^{2,3 and 13}. Yield loss is usually greatest when the disease becomes severe before the grain is completely formed. In Tigray region stem rust is among the most frequently occurring and important disease of wheat⁵.

Several epidemics have been reported at different times due to emerging and re-emerging of virulent races that overcome previously resistant cultivars. Therefore, it is usually suggested that continuous and exhaustive surveys need to be carried out to give a clear picture of the distribution and importance of wheat rusts in general and stem rust in particular. Disease monitoring and surveillance are of paramount significant for sustainable wheat production and tackle food insecurity. The assessment of diseases involves the measurement and

Table 1. Coordinates and elevation range of the inspected districts in South Tigray

District	Altitude range (m)	Coordinates (range)	
		Latitude (N)	Longitude (E)
Raya-Alamata	1494-2512	12°21'-12°23'	039°20'-039°34'
Emba-Alaje	1902-2764	12°52'-12°59'	039°26'-039°33'
Enda-Mekoni	2288-2977	12°44'-12°49'	039°31'-039°32'
Ofla	1848-2727	12°29'-12°39'	039°16'-039°42'
Raya-Azebo	1517-1772	12°39'-12°47'	039°38'-039°42'

quantification of plant diseases and is therefore of fundamental importance in the study and analysis of plant disease epidemics. In addition, information on the currently performances of commercial cultivars is required. Hence, this report presented the results on the distribution and intensities of stem rust and the response of commercial wheat cultivars and differential hosts.

MATERIALS AND METHODS

Description of the Study Areas

Tigray forms the northernmost reaches of Ethiopia and is located between 36° and 40° east longitude and 12.15° and 14°57' north latitude. The region has six administrative zones: South, South-East, East, Central, North-Western, and West. The former one zone is among the major wheat-producing areas of the region⁶. Table 1 presents the detail information on coordinate and elevation of stem rust survey routes.

Survey and Surveillance of Wheat Stem Rust

Wheat stem rust surveys were conducted in five districts of South Tigray from 2010 to 2013 main cropping seasons. The survey trips were made following the main roads and accessible routes in each survey district, and in each available wheat field, stops were made at 5-10 km intervals. A minimum of five stops were made in each wheat field in an "X" pattern depending on the farm size. The assessments were made when the crop growth stage was on average between the medium milk and early maturity stages¹⁹. The prevalence of the disease was computed using the number of fields affected divided by total number of fields assessed and expressed as a percentage. Disease incidence was estimated as the number of infected plants expressed in percentages. Severity was scored visually using modified Cobb's scale¹⁰ and host response¹¹ and the result was summarized by districts and cultivar response.

Disease Monitoring Using Traps

Thirty five stem rust differential hosts were planted in 2014 main cropping seasons in areas having natural epidemics. Each entry was planted in two rows of 1 m

length and spaced 20 far apart. Two entries (Morocco and PBW343) were used at every 20 entries as susceptible checks and spreader. Disease severity was noted using the modified Cobb scale¹⁰ and plant response using¹¹.

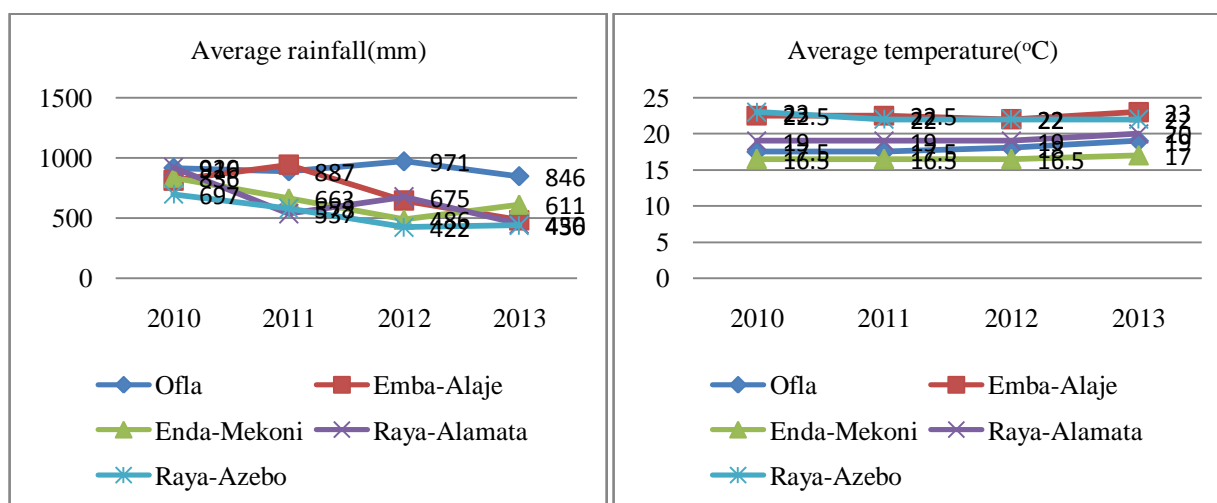
RESULTS AND DISCUSSION

Prevalence, Incidence and Severity of Stem Rust

The result of wheat stem rust surveys conducted for four seasons in 66, 52, 61 and 70 fields in five districts of South Tigray revealed that the intensity of stem rust wide-ranging from lower to complete infection of wheat fields. Of 66, 52, 61 and 70 wheat fields inspected for the four consecutive years, 33.3%, 9.6%, 19.7% and 10% were infected with stem rust, respectively (Table 2). The prevalence of the disease varied across districts of the region. Districts, Raya-Alamata and Raya-Alamata were sustained the higher disease prevalence in all the surveying year. The prevalence of these districts were 55.6% and 81.3%, 16.7% and 18.2%, 60% and 22.7%, and 66.7% and 50% during the consecutive four years, respectively. The prevalence of the disease for the other districts was below 15%. The incidence of the disease was also higher in Raya-Alamata and Raya-Alamata districts. Maximum possible incidence (100%) score of the disease was noted in the former two districts. The overall (zone) mean incidence of the disease was higher in 2010 and 2014 cropping season with score of 15.6% and 14.8%, respectively, while, below 10% in 2011 and 2012 (Table 2). The mean incidence of stem rust was more than 30% in 2010 and 2013 cropping season for these districts. The mean incidence of stem rust in Ofla, Emba-Alaje and Enda-Mekoni districts were below 5%. The seriousness of the disease is explained by the damage it caused known as severity. The severity of the disease was linearly correlated with the incidence that the higher incidence was expressed higher severity. The severity of stem rust was reached 100% in Raya-Azebo district in 2013. The maximum severity of stem rust was 50% and more in Raya-Azebo districts in all the surveyed years and Raya-Alamata during 2010 and 2013 seasons. The mean severity of stem rust ranged from 26.7% to 55% and 5% and 28% in Raya-Azebo and Raya-Alamata districts, respectively. The mean severity of the disease

Table 2: Prevalence and intensity of stem rust in five districts of South Tigray from 2010-2013

2010						
District	Fields inspected	Prevalence (%)	Incidence(%)		Severity(%)	
			Range	mean	Range	mean
Raya-Azebo	16	81.3	0-100	42.3	5-80	26.7
Raya-Alamata	9	55.6	0-100	33.3	5-50	12.5
Ofla	16	12.5	0-7.4	0.6	Tr-5	0.5
Enda-Mekoni	14	7.1	0-5	0.4	Tr-5	0.4
Emba-Alaje	11	9.1	0-15	0.98	Tr-10	0.9
Total/mean	66	33.3	0-100	15.6	0-80	8.5
2011						
Ofla	16	0.0	0	0	0	0
Emba-Alaje	11	9.1	5-5	5	5-5	5
Enda-Mekoni	8	0.0	0	0	0	0
Raya-Azebo	11	18.2	0-5	0.1	10-50	30
Raya-Alamata	6	16.7	5-5	0.3	5-5	5
Total/mean	52	9.6	0-5	0.2	5-50	13.3
2012						
Ofla	9	0	0	0	0	0
Emba-Alaje	10	10	0-10	1	5	5
Enda-Mekoni	10	10	0-15	1.5	20-20	20
Raya-Azebo	22	22.7	0-30	3.5	20-60	40
Raya-Alamata	10	60	0-100	32.8	10-30	28
Total/Mean	61	19.7	0-100	9.5	10-60	30.3
2013						
Ofla	30	3.3	0-20	1	0-20	20
Emba-Alaje	23	0	0	0	0	0
Enda-Mekoni	7	0	0	0	0	0
Raya-Azebo	4	50	0-100	31.2	0-100	55
Raya-Alamata	6	66.7	0-50	42	0-60	23.3
Total/Mean	70	10	0-100	14.8	0-60	32.8

**Figure 1:** The average rainfall (mm) and temperature (°C) of each district across years

was each 20% in Ofla and Enda-mekoni districts in 2013 and 2012 season, in that order. Generally, the intensity of stem rust lower in the highland districts namely Ofla, Enda-Mekoni and Emba-Alaje (Table 2).

The most possible reason for the higher epidemics in Raya-Azebo and Raya-Alamata districts could be due the warmer environmental conditions (Figure 1) and suited

relatively at lower elevation (Table 1). Earlier studies also indicated that stem rust was a threat to wheat production below 2300 m elevation⁸. On the other hand, lower development of stem rust in the remaining three districts may probably be due to cool environmental condition during the growth stages of the crop (Figure 1) and most of the inspected fields for having altitudes above 2300 m

Table 3: Prevalence and intensity stem rust and response of cultivars South Tigray 2011-2014.

Variety	Altitude (m)	range	Total field	Prevalence (%)	Incidence (%)		Severity (%)	
					Range	Mean	Range	Mean
Kubsa(HAR 1685)	2256-2715		37	10.8	0-100	6.4	0-100	52.1S
Local mixture	1517-2680		66	33.3	0-100	12.1	0-100	11RMS
Dashen	1494-2557		13	15.4	0-10	1	Tr-20	10MSS
Shina(HAR 1868)	2110-2977		12	0	0	0	0	0
Hawi(HAR 2501)	1522-2577		17	17.6	0-50	4.4	0-5	6.2RS
Digelu	2125-2756		27	0.0	0	0	0	0
Kakaba	1611-2492		31	3.2	0-10	1	0-10	5R
Danda'a	2125-2590		23	0	0	0	0	0
Shorima	2531		1	0	0	0	0	0
Mekelle-1	1550		3	33.3	0-100	33.33	0-100	33.3S
Mekelle-4	1977-2617		3	33.3	0-100	33.33	0-100	33.3S
Unknown improved	2002-2472		12	41.7	0-100	26.7	0-100	8.8S

Table 4. The severity (%) and reaction of wheat differentials to stem rust

Differentials	Response	Differentials	Response
Prelude*6/Reliance	0	Line E/Kavkaz	5R
ISr6-Ra	0	Sr31(Benno)/6*LMPG	0
Na 101/6*Marquis	70S	Seri 82=VEE5=FALAT	0
Red Egyptian/CS	35S	CnsSr32 AS.	0
W2691Sr9b	40S	RL 5405	10MR
CnsSr9g	50S	Mq(2)5*G2919	0
W2691Sr10	5R	Cook	60S
ISr11-Ra	5R	W2691SrTt-2	10R
St464Sr13	40S	RL 6081	20MS
LineA Seln	40S	RL 6082	30S
Combination VII	0	RL 6088	20MS
T.mono. deriv.	5R	Taf-2	40S
LcSr24Ag	5R	Golden Ball deriv.	10MS
Supseri	0	W2691SrGtGt	20MS
Coorong (Triticale)	0	CnSSrTmp	10MR
W2691Sr28Kt	5R	BtWld	10R
Chris	0	Morocco	10MS
Norm	0	PBW343	10R
BtSr30Wst	0		

(Table 1). Previous studies reported that cool environmental conditions with higher rainfall pattern are not more suitable for the development of stem rust^{9 and 11}.

Responses of Wheat Cultivars to Stem Rust

This study ascertained that most of the high yielding commercial bread wheat cultivars were found susceptible to the stem rust. The distribution of the disease ranged from 3.2% for Kakaba and 41.7% for unspecified different bread wheat cultivars (Table 3). The highest incidences 100% was registered for Kubsa (HAR 1685), local mixtures, Mekelle 1, Mekelle 4 and unknown bread wheat cultivars. The severity of the disease is explained by the damaged exhibited. Similarly, the former indicated five

cultivars exhibited 100% severity level. Generally 58.3% of the cultivars were susceptible to the populations of the pathogen (Table 3). The assessment of commercial bread wheat cultivars for the last decades showed they have become more susceptible to stem rust⁵. This could be due to the availability of virulent races of stem rust in the country in general^{3 and 4} and Tigray region in particular¹. On the other hand, few recently released varieties were found satisfactory resistant to the stem rust in the region. Cultivars Shina (HAR 1868), Digelu, Danda'a, Shorima and Kakaba were found free and/or resistant to the pathogen population. However, the variety Digelu was succumbed by new race (TKTTF) in other parts of the country (www.ustracker.cimmyt.org). The local mixtures mainly durum wheat origin was found

resistant to moderately susceptible. Local cultivars were important sources of resistance for stem rust due to the existence of local diversity³.

The Response of Wheat Differentials to Stem Rust Population

Although resistance has not been permanent, combination of single host genes for resistance have been effective in controlling stem rust from several too many years and in many countries^{9, 15 and 16}. Hence, evaluating and screening of different *Sr* genes to the pathogen populations is a critical and pertinent for breeding programs. It is generally investigated that stem rust showed relatively light infection level during the trap surveying period (2014). It was evident that the majority (65.7%) of the resistance genes were found affected by the stem rust populations. Nine *Sr* genes were ineffective against the stem rust populations exhibited susceptible reaction with severity levels that ranged from 30% to 70% (Table 4). In contrast, 34.3% of the *Sr* genes were effective against disease that could be used in breeding strategies.

CONCLUSION

Ethiopia is hot spot area for the development of highly variable stem rust races. Therefore, it is imperative for research institutions to monitor pathogen population over time, to track further virulence evolution and to ensure that currently resistance genes as well as the commercial wheat cultivars are still effective or resistance. Durable rust resistance may be achieved by pyramiding, that is, accumulating several effective resistance genes in one cultivar helped to extent the longevity of resistance against the disease.

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