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Review Article

The Current Threats of Wheat Stripe Rust (*Puccinia striiformis f.sp.tritici*) Disease and the Consequence for Food Security in Ethiopia

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Abstract: Wheat is the fourth most important staple food crop in Ethiopia and grown in a wide range of agro-ecology. It accounts more than 15% of the total cereal output. The country is the second largest wheat producer in sub-Sahara Africa, and the crop is becoming a key strategic crop for improving food security. However, the national average yield is 2.73 tones/ha, which is far less than from the potential yield of 8 to 10 tones /ha. This low productivity of wheat in Ethiopia is attributed to a number of factors, including biotic (diseases, insect pest and weeds) and abiotic (moisture, soil fertility and etc.). Among biotic factors stripe rust disease is the most series and wheat production bottle necks issue in the country. And in most wheat-producing areas, yield losses caused by stripe rust ranged from 2.7 to 96.7% depending on the degree of susceptibility of the cultivar, timing of the initial infection, rate of disease development, areas of hotspot and duration of disease. Despite its occurrence and distribution much still needs to be understood about its impact and management options of the disease. As a result, this review work was initiated to provide wakefulness and show the present threats of wheat stripe rust disease in Ethiopia. And the review was carried out from associated journals, theses, books and research papers. This review result revealed that knowledge gap, lack of attention, lack of coordination among Regions, Zones, Districts and Sectors, Shortage of resistant varieties and high fungicide price are some of the identified reasons in Ethiopia for the disease to occur regularly and epidemically as well. As the result of this, every year there is more than 10% yield loss (275,000 tones) that costs 94, 795 millions of US dollars. However, during epidemics the loss is much higher than this. Consequently, the disease is considered as one of the constraints for the country not to produce sufficient amount of wheat grain. As a result, in each year the country is imposed to continue importing millions of quintals of wheat grain from abroad that demands high foreign currency. Therefore, this review result conclude that to overcome this challenge the country has to implement more efforts in developing an effective and efficient wheat stripe rust management strategy.

Keywords: Stripe Rust, Resistant Varieties, Fungicides, *Puccinia striiformis*

1. Introduction

Wheat is the most widely grown crop globally and source of food and lively hoods for over one billion people. It is the fourth most important staple food crop in Ethiopia [8]. In the country wheat is cultivated on a total area of 1.7 million hectors with estimated annual production of 4.6 million metric tons [6].

Ethiopia is the second largest wheat producer in sub-Sahara Africa, and the crop is becoming a key strategic crop for improving food security in the country [15]. And it grows in a wide range f agro-ecology [8]. The national average yield is 2.73 tones/ha [6], which is far less than from the potential yield of 8 to 10 tones /ha. This low productivity of wheat in Ethiopia is attributed to a number of factors including biotic (diseases, insect pest and weeds) and a biotic (moisture, soil fertility and etc.). And Among these factors' disease play a significant role in yield reduction [17].

Rust diseases are historically the most damaging diseases of

wheat. And their frequency, extent and impact have increased significantly in the last two decades causing national and global concerns.

Their high capacity of developing new races, make most wheat varieties vulnerable to them. Wheat rust diseases are caused by fungal pathogens belonging to the *Puccinia* species. The three major rusts are stripe rust (*Puccinia striiformis f.sp. tritici*), stem rust (*Puccinia graminis f.sp.tritici*) and leaf rust (*Puccinia reconidata* f.sp.*tritici*). All of them are air borne fungi whose spores can spread rapidly over far distances by wind [17].

Among wheat rust diseases stripe rust is very important particularly in central and west Asia, North and East Africa, Australia, Europe, China and USA. The breakdown of resistance conferred by the emergence of Yr9 virulent races of *Puccinia striiformis f.sp.tritici* in the late 1980s resulted in major epidemics of the disease that challenged wheat production in many countries of the world including Ethiopia [5].

In 2010, Ethiopia experienced a devastating stripe rust epidemic that affected more than 600,000 ha of wheat fields caused yield loss up to 34% [12].

And lead to an expenditure of more than $ 3.2 million on fungicides [9]. While significant wide spread losses were still realized in all wheat growing areas of the country [1]. Therefore, this review was carried out to provide knowledge and perspectives and illustrate the present threats of wheat stripe rust disease in Ethiopia.

2. Epidemiology of Wheat Stripe Rust

2.1. The Pathogen

The pathogen (*Puccinia striiformisf.sp.trtici*) is considered to be an obligate parasite. And it infects the green tissue of wheat any time from one leaf stage to mature plant.

2.2. Symptom

(Source: Alfredo et al. 2009)

Figure 1. *Typical symptoms of stripe rust.*

Stripe rust symptom would appear about a week after infection and sporulation starts about two weeks of post infection and the first sign of stripe rust is the appearance of yellow streaks (pre-pustule), followed by small, bright, yellow elongated uredial pustules arranged in conspicuous rows on the leaves, leaf sheathes, glumes and awns (Figure 1). Mature pustules will break open and release yellow orange masses of uredio spores (Figure 2). The infected tissue may become brown and dry as the plant matures or become stressed. And sever early infection can result stunting plant [5].

(Source: Alfredo et al. 2009)

Figure 2. *Stripe rust infested field.*

2.3. Favoring Conditions

2.3.1. Moisture

The pathogen spore to germination, grow and survive, it requires at least 3 hours of moisture on the host surface [5].

2.3.2. Temperature

Temperature initially affects spore germination and growth. And it also affects infection capability and sporulation. The disease principally attacks the wheat grown in cool climate (3°C to 20°C) [13].

2.3.3. Wind

Spores are produced in huge numbers on the upper surface of the leaves. And once they become air borne, their spread is a matter of chance. Most will land on soil or on other plants, while some stay air bone until sun light kills them in a few days, however, they are produced in such high numbers that some land on other living wheat plants [4].

And Wind plays an important role in spreading the pustules magnanimously. Urediospores can be easily taken to travel to long distances, with the possibility of migrating from continent to continent (Figure 3) [4].

2.4. Adaptation Strategies

Wild grasses were suggested to play a role in the over seasoning of the pathogen as urediospores, especially in the mountains [17]. The complete life cycle of the pathogen was not known until 2010, when an alternate host i.e., Berbery plant was identified [11].

The life cycle of the pathogen consists of Pycniospores and aeciospores on Berberis and Urediospores and Teliospores on wheat. And Basidiospores are produced from teliospores very quickly [11].

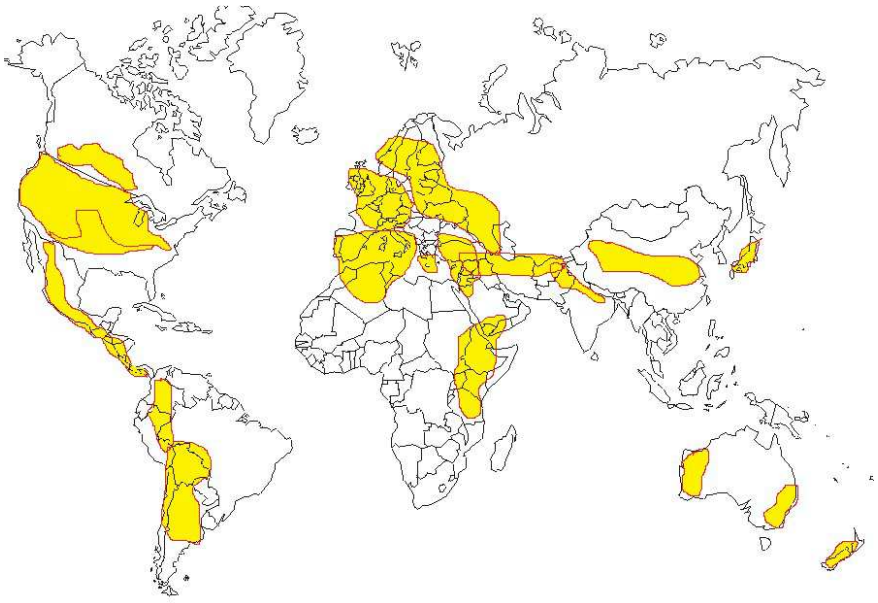

Figure 3. *Spread of wheat stripe rust (Source: Chen, 2005).*

2.5. Population Genetics and Molecular Diversity

The genus *Puccinia* is the most economically important of the *Pucciniaceae* family and consists of more than 3,000 species. Different formae spaciales of *Puccinia striiformis* caused stripe rust of cereal and grasses [4].

There is genetic variation in *Puccinia striiformis tritici* population. Mutation, Somatic and sexual recombination are the main factors causing the variation. In addition in small population; Selection, Migration and random genetic drift are also responsible for genetic variation [9].

2.6. Epidemics of the Disease

The most and recent destructive epidemics have taken place in China, Northern and Eastern Africa, Western Asia, Central Asia and Middle East, and the epidemics may become even more aggressive with races that can tolerate and develop in higher temperatures [9]. According to [14] the new races of yellow rust have significantly increased adaptation to warmer temperatures and therefore continue to cause disease epidemics.

3. Damage of the Disease

Stripe rust of wheat reduces the yield and quality of the grain and forage. The disease can cause up to 100% yield loss, if infection occurs very early and the disease continues to develop during the growing season provided susceptible cultivars [4]. As the disease level increases the yield loss also increases. This indicates that there is a direct linkage between disease severity and yield loss (Figure 4) [16].

In addition to the yield loss caused by the disease it is known in causing shriveled harvested seeds and low in stored food reserve for the next round of crop growth [3].

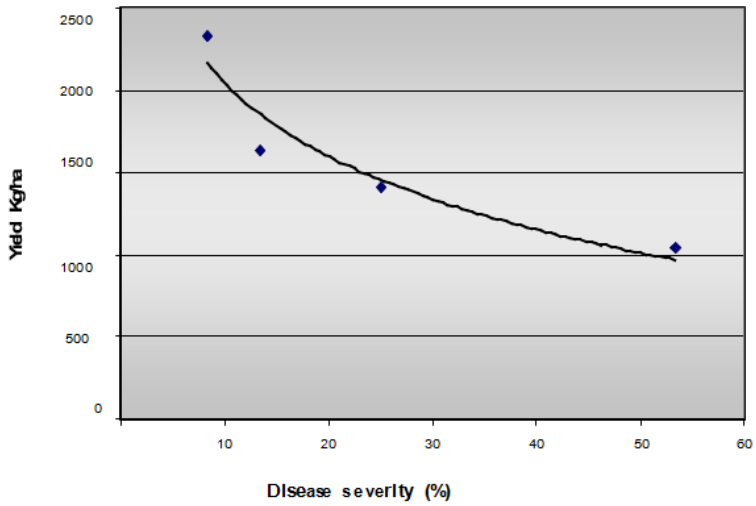

Figure 4. *Disease severity and yield loss of wheat stripe rust (Source: Syednadeem et al., 2007).*

4. Impact of the Disease

4.1. Global

Since 2009/10 the occurrence of an outbreak of Yr27 an aggressive new strain, stripe rust has been caused high yield loss (5-25%) in different countries (in Azerbaijan, Iraq, Kenya, Morocco, Syria, Turkey, USA, China, Europe and Australia). And this yield loss caused food price increment that leads to threatening of food security and livelihood of many low-income countries [17].

4.2. National

Unlike other staple grains, in Ethiopia in each year wheat is imported in large volumes. And the percentage of domestic wheat consumption coming from import varies between 25 and 35% depending on the size of the harvest and other factors [8].

The Government has been importing about 770,000 tons of wheat grain and spent about 265,425 millions of US dollars per year and subsidizes the import to make bread more affordable to poor consumers [7].

And on the other hand in the country the disease has been occurring regularly in high land areas (over 2000 masl) [12], and caused more than 10% yield loss (275,000 tones) that costs 94, 795 millions of US dollars [7]. As the result of this, Wheat stripe rust is considered as the main factor for the country not to produce sufficient amount of wheat grain. This imposed the country to continue importing wheat grain that put critical burden on the country's economy.

However, in the country stripe rust occurs as major epidemics in 1970, 1977, 1983, 1986, 1988 and 1990 caused high yield reduction. Particularly in the year 1988 the yield loss caused by the disease was sever in bread wheat, and it was as high as 58% [12]. In the year 2010, the epidemic covered almost all wheat growing Regions of the country except Tigray [10]. Research results showed that in Amhara Region the yield loss due to the epidemic in 2010 was ranged from 41.5 to 44% [12].

Table 1. *Yield loss of wheat due to stripe rust in Amhara Region during 2 010.*

Cultivars	Yield/ha		
	Sprayed (kg)	Non sprayedS (kg)	Loss (%)
HAR-1685	2564.95	1499.62	41.5
HAR-604	2667.55	1503.67	43.6

5. Struggling Wheat Stripe Rust

Over the past decades many countries have been managed the disease using resistant varieties. Whereas, today the situation and the threat form is different from the past, due to climate change that encourages the emergence of new races that overcome the currently resistant varieties. And low-income countries particularly need to put in place strategies now for immediate action, medium term protection and long term research efforts to develop new wheat varieties that resist the changing stripe rust disease [10].

This is because the greatest threat lies in wheat dependent developing (low income) countries that could cost billions of dollars in attempted control and lost agricultural output. The resulting spike in food prices would push bread and other basic wheat based products out of the reach of many, with potential political implications.

One of the core issues for planners and policy makers is that stripe rust doesn't respect Zonal, Regional and National borders. This is because spores of the disease can quickly multiplied and blow from one zone to another zone and from one region to another Region as well as from one country to another country.

6. Constituents of Wheat Stripe Rust Disease Management Options

6.1. Surveillance, Preparedness and Rapid Reaction

The Regional and National Plant Health Laboratories need up graded skills and facilities to provide Regional and National early warning services at the field level. This rapid Regional and National reaction network is vital to monitor new stripe rust incidence and spread.

This is because stripe rust can cover large area within 24 to 48 hrs. And it is believed that the Regional rapid reaction is the first line of defense. And more efforts are needed in every Region and country to develop a stripe rust surveillance and early warning system that links field level information to other parts of the country and beyond. And this needs to have a strong link and contact with another regions and neighboring countries [10].

6.2. Resistant Varieties Development

In Ethiopia for the past 20 to 30 years, farmers have been planting the same varieties from year to year. However, this kind of practice is not advisable particularly in a situation where stripe rust races are mutating and new ones are emerging much more rapidly than the past. As a result of this, breeding of disease resistant varieties is the chief line of long term defense against stripe rust. This is because the current epidemic threat is the occurrence of aggressive new stripe rust [8].

6.3. Use of Fungicides

Even though, the cost of fungicides is not always affordable to many farmers of the country, foliar fungicides can effectively control stripe rust, when applied at booting growth stage of the crop. This is because fungicides provide maximum protection for the upper leaves that contribute most of the energy used to produce grain. Besides, fungicides provide a practical and rapid response solution as well.

7. Conclusion and Recommendation

Wheat is the fourth most important staple food crop in Ethiopia and grown in a wide range of agro-ecology. And it

accounts more than 15% of the total cereal output. The country is the second largest wheat producer in sub-Sahara Africa, and the crop is becoming a key strategic crop for improving food security. However, the national average yield is 2.73 tones/ha, which is far less than from the potential yield of 8 to 10 tones /ha.

This low productivity of wheat in Ethiopia is attributed to a number of factors, including biotic (diseases, insect pest and weeds) and abiotic (moisture, soil fertility and etc.). Among biotic factors stripe rust disease is the most series and bottle neck issue in the country's wheat productivity and production. In most wheat-producing areas of the country, yield losses caused by stripe rust ranged from 2.7% to 96.7% depending on the degree of susceptibility of the cultivar, timing of the initial infection, rate of disease development, areas of hotspot and duration of disease.

This review result revealed that knowledge gap, lack of attention, lack of coordination among Regions, Zones, Districts and Sectors; Absence/shortage of resistant/tolerant varieties and high fungicide price are some of the identified reasons in Ethiopia that create fertile ground for the disease to occur regularly and cause more than 10% yield loss (275,000 tones) that costs 94, 795 millions of US dollars per year. However, during epidemics the loss is much higher than this. Consequently, the disease is considered as one of the constraints for the country not to produce sufficient amount of wheat grain. This phenomenon imposed the country to continue importing millions of quintals of wheat grain from abroad that demands high foreign currency in each year.

In conclusion, this review result achieves that in the country unless the identified wheat stripe rust management constraints are rectified the menacing effect of the disease will continue. As a result, there will be an increasing cost of wheat imports which will put critical burden on the country's economy.

Therefore, it is further recommended that to provide sustainable wheat production in the country and minimize the economic burden observed as a result of wheat grain import, an effective and efficient wheat stripe rust management strategy has to be implemented.

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