

Response of Improved Durum Wheat (*Triticum durum* L.) Varieties to Wheat Stem Rust in Central Ethiopia

Abiyot Lemma¹, Getaneh Woldeab² and Selvaraj T³

¹EIAR, Worer Agricultural Research Center, P.O. Box 2003, Addis Ababa, Ethiopia

²EIAR, Ambo Plant Protection Research Center, P.O. Box 37, Ambo, Ethiopia

³Ambo University, P.O. Box 19, Ambo, Ethiopia

Abstract

Wheat stem rust caused by *Puccinia graminis* f.sp. *tritici* is amongst the biotic factors which causes up to 100% yield loss during epidemic years. Therefore, the present study was carried out to observe the reaction of improved durum wheat varieties to virulent stem rust isolates at seedling growth stage and to stem rust population at adult growth stages. The finding of this experimental study was based on isolation and multiplication of virulent races of *P. graminis*, then ten durum wheat varieties including the susceptible check morocco were tested for the virulent isolates at seedling growth stage; and the reaction of these varieties under natural field conditions were evaluated in the Eastern and Western Showa of Central Ethiopia at adult growth stages. At seedling growth stage, 60% of varieties tested with the virulent stem rust isolate from Debrezeit exhibited resistance, while all varieties were resistant to Ambo isolate. Ten durum wheat varieties evaluated at adult plant growth stage to stem rust population of Debrezeit (Eastern Showa) showed severities of 20S in the variety Geredo to 70S in the variety Foka, while at Ambo (Western Showa) only the susceptible check, Morocco was infected up to 20S. The result indicated that stem rust from Debrezeit was virulent to durum wheat varieties as compared to the Ambo population.

Keywords: Durum wheat; *P. graminis*; Reaction; Ambo; Debrezeit

Introduction

Wheat is the most important cereal crop in the world and widely grown occupying 17% of the world cultivated land [1,2]. Ethiopia is the second largest producer of wheat in sub-Saharan Africa [3] and it is represented as hexaploid (bread wheat) and tetraploid (durum and emmer wheat types) [4]. The crop has considered as the main staple food of Ethiopian population particularly in highlands of the country [5] where it has produced in a large volume and 95% of the total production is produced by small scale farmers. Wheat accounts for 17.5% of major crops produced in Ethiopia [6]. Currently it ranks second both in terms of volume of production and productivity after Maize and third in terms of area coverage after Maize and Tef [7].

Durum wheat which was believed to be originated in the Abyssinian and Mediterranean [8] is traditionally grown on heavy black clay soil (vertisol) and it has very narrow adaptation and lower yield potential as compared to bread wheat [9]. The grain is differentiated by its big size and weight, mainly suitable for pasta, macaroni, pastini and other manufacturing products. Besides, its stalk as other cereal crops residue is a good source of animal feed and serves as mulch for different agronomic practices in Agriculture.

The production and productivity of wheat crop in Ethiopia has increased in the last decades, though the national average yield has not exceeded 1.7 tones/ha [7]. This is by far below the world's average yield/ha which is about 3.3 tones/ha [10]. This low yield is attributed to multi-faced abiotic and biotic factors such as cultivation of unimproved low yielding varieties, low and uneven distribution of rainfall, poor agronomic practices, insect pests and serious disease like rusts [11].

Rust fungal pathogens are among the major stresses that cause high yield losses in wheat crop. Over 30 fungal wheat diseases are identified in Ethiopia, stem rust caused by *Puccinia graminis* f.sp. *tritici* is one of the major production constraints in most wheat growing areas of the country; causing yield losses of up to 100% during epidemic years [12].

The high lands of Ethiopia are considered to be hot spot for stem rust

development where an estimated loss due to this disease ranges from 40% in endemic areas to 100% where epidemics occur on susceptible varieties [13]. Epidemics of stem rust occurred in 1993 resulted in a tremendous loss of grain in the variety Enkoy which ranged from 67 to 100% in Arsi and Bale zones of Ethiopia and which causes for the demise of this variety [14].

Recent studies in the country showed that most previously identified races were virulent on most of varieties grown in the country [12,15,16]. This may show that there is potential danger of resistance breakdown in Ethiopian released bread, durum and emmer wheat varieties. Resistance could be expressed as reduction in number of lesions, a reduction in the size of sprouting area, an increase in the length of the latent period and a reduction in length of sporulating period [17]. Selection of Indigenous germplasm, selection from introduction, hybridization and evaluation of selected lines are the breeding methods used for screening the targeted disease problem and yield improvement by the national durum wheat program in Ethiopia [18]. Therefore the present study was carried out to determine the reaction of improved durum wheat genotypes to virulent isolates of stem rust at seedling growth stage and to stem rust population under natural field condition at adult growth stage.

Materials and Methods

Adult plants and seedlings of ten commonly grown improved

*Corresponding author: Abiyot Lemma, EIAR, Worer Agricultural Research Center, P.O. Box 2003, Addis Ababa, Ethiopia, Tel: 00251-911332353; E-mail: alemma2009@gmail.com

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durum wheat varieties and a susceptible check, Morocco (Table 1) were screened against stem rust populations of Debrezeit and Ambo under natural field conditions, and with one stem rust isolate each from Debrezeit and Ambo in the green house. The varieties were included in the Ethiopian Wheat Rust Trap Nursery (WRTN) and were tested at many locations. For this study, data were collected from Debrezeit Agricultural Research Center (DZARC) and Ambo Plant Protection Research Center (APPRC) experimental fields.

Response of durum wheat varieties to stem rust population under natural field conditions of DZARC and APPRC at adult growth stages

The ten durum wheat varieties were planted at Debrezeit Agricultural Research Center (DZARC) and Ambo Plant Protection Research Center (APPRC) experimental fields in un replicated trials with two rows per plot. Each plot has a size of 1 m long with two rows and 20 cm spacing between rows. Plant population (density) were regulated to favor maximum disease development in which the plant is able to express its genetic resistance potential, and agronomic practices which ensures optimum plant growth and development was followed. At APPRC, the test materials were planted on July 14, 2009, while it was planted in the first week of July at DZARC. Artificial fertilizers were applied at the rate of 50 kg Urea (N=46 kg/100 kg) and 100 kg of DAP (N P K=18:18:0). Three-four times hand weeding was carried out during the crop growing season to make the plots were weed free at both locations. Data were scored during October, in which the disease was reached at its maximum severity level ([19] [20] using Peterson et al., [21] severity scoring scale (Table 2), and the crop response classification scale of Stubbs et al. ([22] under field conditions. Based on the size of the pustule, Stubbs et al. (1986) has classified the response as: 0 when no visible infection has observed; Resistant (R), when necrotic areas are with or without small pustules; Moderately Resistant (MR), when small pustules are surrounded by necrotic areas; Intermediate (M), when pustules of variable size & when there is some necrosis or chlorosis; Moderately Susceptible (MS), when there is medium sized pustules and no necrosis but some chlorosis are observed; and Susceptible (S), for large pustules with no chlorosis and necrosis have observed on the crop.

Response of improved durum wheat varieties to stem rust isolates at seedling stages

Stem rust isolate from Debrezeit (TTTTF) and from Ambo

Variety	Pedigree
Cocorit-71	RAE/4* TC 6011 STW 63 \3/AA S, DZ 27617- 18-64-0M
Gerardo	VZ 466/61-130xGII "s", CM 9605
LD357	CI 8188 No. 58-40
Boohai	Cr "s"/21563/61-130xLds candea II=Coo s/CII,CD 3062-Bs-OGR
Foka	COCRIT 71/CANDEAL-II, CD 3369
Kilinto	ILLUMILLO/INRAT69//BHA/3/HORA/4/CIT 71 JORI, DZ 918
Bichena	Illumillo/ cocorit 71, DZ 393-2
Robe (DZ1640)	Hora/Cit's//Jo's'/GS's'/3/Some's'/4/Hora/Raspinegro//CM9908/3/
Ude (CD 95294-2y)	chen / ALTAR 84// Aid CD 95294-2y
Yerer(CD 94026-4y)	chen/Tez/3/Guil//cII CD 94026-4y-040m-030y-pAp-0y
Morocco	

Source Kulumsa Agricultural Research Center (KARC)

Table 1: List of durum wheat lines used for screening against stem rust and their pedigree

Actual percentage	Visual percentage
0.37	1
1.87	5
3.7	10
7.4	20
11.1	30
14.8	40
18.5	50
22.2	60
25.9	70
29.6	80
33.3	90
37.0	100

Table 2: The actual percent and visual percentage through considering combination of pustule size and distribution of severity of rust disease [21].

(PTKTK) were multiplied on the universally susceptible variety Morocco. On the other hand, six seeds from each of the ten improved durum wheat varieties and a susceptible check Morocco were sown in plastic pots containing soil, compost and sand in the ratio of 2:1:1 using Complete Randomized Design (CRD) in a greenhouse. When the seedlings were 7 days old (the first leaf is fully expanded and the second leaf is just emerged), they were inoculated with one race from Debrezeit and another from Ambo and maintained in greenhouse. Data on infection types were recorded 14 days after inoculation according to the host response and infection type description given by Stakman et al. [23] (Table 3).

Results and Discussion

In this study, adult plants and seedlings of ten commonly grown improved durum wheat varieties and a susceptible check, Morocco (Table 1) were screened against stem rust populations of Ambo and Debrezeit under natural field conditions, and with two virulent isolates of *P. graminis* f.sp *tritici* in greenhouse test. The results showed that at adult plant growth stages the test varieties reacted differently to stem rust populations of Ambo and Debrezeit. At Ambo experimental field, these varieties were very resistant to the existing stem rust populations except on the universally susceptible variety Morocco, this variety was infected by stem rust up to 20S (Table 4). Different result was observed at Debrezeit experimental field where except the variety LD 357 which showed moderately susceptible/moderately resistant reactions, all the rest were susceptible/moderately susceptible to the stem rust populations. The universally susceptible variety Morocco was infected up to 60S. This data showed that the pathogen populations at the two centers were probably different.

The green house test at the seedling growth stages revealed that none of varieties were immune to both Ambo and Debrezeit isolates/ races. All varieties tested with Ambo stem rust isolate/race "PTKTK" at seedling stage had resistant reactions of "1- 2" in a "0-4" scoring scale. The only variety which showed a susceptible reaction "4" was the susceptible check Morocco. The durum wheat varieties tested were resistant/effective to the stem rust population as well as to the isolate of Ambo at both growth stages. However, the Debrezeit stem rust isolate/race "TTTTF" used in the greenhouse test was virulent when it was compared with Ambo's isolate. In the greenhouse test, 40% of the durum wheat varieties included in the study was not effective, while 60% or six varieties namely LD 357, Bichena, DZ-1640, Foka, Kilinto and Yerer were effective to this isolate. Nevertheless, at adult plant growth stage, the later four varieties were non-effective under natural field conditions of Debrezeit. The reason could probably be the difference in virulence between the stem rust field population and

Class	IT	Description of symptoms
Immune	0	No sign of infection to the naked eye
Very Resistant	0;	No uredia, but distinct flakes of varying sizes, usually a chlorotic yellow but occasionally necrotic
Resistant	1	Small uredia surrounded by yellow chlorotic and necrotic area
Moderately Resistant	2	Small to medium sized uredia, typically in a dark green island surrounded by a chlorotic area
Mesothentic or Heterogeneous	X	A range of infection type from resistant to susceptible scattered randomly on a single leaf caused by a single isolate not a mixture
Moderately Susceptible	3	Medium sized uredia. Usually surrounded by a light green chlorotic
Susceptible	4	Large uredia with a limited amount of chlorosis: may be diamond shaped
Modified characters		
Lower uredinia	=	uredia much smaller than typical and at the lower limit of the infection type
Small uredinia	-	uredia smaller than normal
Larger uredinia	+	uredia larger than normal
Largest uredinia	++	uredia much larger than typical and at the upper limit for the infection type

Table 3: Description of infection types used in classifying the reactions to stem rust on seedling wheat leaves as it was adopted from [23].

Variety	Reactions of durum varieties to stem rust at			
	Adult plant growth stage		Seedling growth stage	
	Ambo (%)	Debrezeit (%)	PTKTK / Ambo isolate (0-4 score)	TTTTF/DZ isolate (0-4 score)
Cocorit 71	0	40MS	1*	3*
Geredo	0	20MS	1	3*
LD 357	0	30MS/MR	1	2
Boohai	0	40S/MS	1	3*
Foka	0	70S	1	1
Kilinto	0	60S	1	2
Bichena	0	20S/MS	1	2
DZ 1640	0	40S	1	2
CD-95294-2y (Ude)	0	40MS/S	2	3
CD-94026-4y (Yerer)	0	20S/MS	1	1
Morocco(Suscp.check)	20S	60S	4	3*

Table 4: Reaction of some durum wheat varieties to stem rust at Adult and seedling growth stage of Ambo and Debrezeit during 2009 growing season.

the isolate used in the greenhouse. According to this study, varieties Foka and Yerer had better resistance to stem rust to both Ambo and Debrezeit stem rust isolates at seedling stage. In addition to those varieties LD 357, Bichena, DZ-1640 and Kilinto were resistant to Debrezeit stem rust isolates and very resistant to Ambo stem rust isolates at seedling stage. Cocorit and Geredo which were found to be resistant at seedling stage for two Debrezeit isolates of *P. graminis* f.sp. *tritici* in 2003 [24] were found to be susceptible at seedling stage for the virulent isolate of Debrezeit this year. Generally, the seedling test with isolates from Debrezeit showed that 60% of the varieties were resistant to the currently available virulent race, and therefore, Ethiopian land races could be a valuable source of resistance to the stem rust virulent race(s), which is in harmony with reports of Mengistu and Yeshe [25]. They mentioned as the large proportion of Ethiopian durum wheat accessions are resistant or moderately resistant to stem rust, and the land races are found to be a good source of resistance to stem rust. At Ambo, all varieties could be grown as long as the population of stem rust is not changed. So, this study indicated the type of varieties we have at hand in regard to infection by stem rust.

Conclusion

All the tested durum wheat varieties were resistant to stem rust of Ambo at adult growth stages under natural field condition, while 20MS in variety Geredo to 70S in variety Foka were recorded in the Debrezeit experimental field. The seedlings of all ten Durum wheat varieties tested with Ambo stem rust isolate showed resistant reactions, while 60% of these varieties were resistant to Debrezeit isolate. Therefore, the development of stem rust under natural field condition was favored by the environmental condition at Debrezeit than at Ambo. Moreover the pathogen populations in the two locations were different, in which the pathogen from Debrezeit is virulent.

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