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Research Article

Characterization of durum wheat accessions for their Adult Plant Resistance (APR) Against Stem Rust Races

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ABSTRACT

Stem rust causes a huge amount of loss on wheat productivity in Ethiopia. It is due to wheat varieties are released without conferring resistance gene. Identification of each available resistance genes in the accessions is very important. The aim of the research was to select durum wheat accessions for their adult plant resistance against stem rust. A total of twenty durum wheat accessions were tested six (TTRTF, TKTTF, TRTTF, TTTTF, TTKSK and JQCRC) stem rust races. The experiment was conducted at Debre Zeit Agricultural Research Centre using augmented design at nursery and main research field. Accessions were evaluated by slow rusting parameter Average Infection Coefficient (AIC), Area Under Progress Curve (AUDPC), Terminal Rust Severity (TRS) and Disease Progress Rate (DPR). As a result; accession 12, accession 1 and accession 2 has low rusting values with resistance to all selected races while; accessions 17 and accessions 18 had highest AIC, AUDPC, TRS and DPR at high susceptibility value. Identified accessions from this study; gives for wheat breeders good resources for improving stem rust resistance. The result from this experimental study shows that cultivars had diversity regarding to resistance reaction ranging from resistance to susceptible accessions.

Keywords: Resistance, Accessions, Slow rusting, Races

INTRODUCTION

Wheat is important crop for food security and constituted as strategic crop for poverty alleviation in the world [1]. Ethiopia is the first and largest wheat producer in sub-Saharan Africa [2]. [3] indicated that demands are progressively growing withthe elevations of human population [4] however, world wheat productivity is growing at of 1% rate. The increase population growth sub-Saharan Africa will increase wheat demand in Ethiopia as a major source for consumption is about 38% at 2023 [5] and the is due to the establishment of many food processing industries.

In Ethiopian regions at highland areas such as; south nations at, Oromia and Amhara nowadays tigray areas are potential wheat producing regions. Productivity of wheat at in Oromia region (2.97 tons/ha) followed by SNNPRS (2.67 ton/ha) and Amhara (2.53 ton/ha) [6], mean of wheat production of 2.736 t/ha is low compared to the world's average, 3.65 t/ha. To reduce the low productivity of durum wheat is important to find safe and economical management options [7]. Reported national wheat improvement programs needs to undertake evaluation across wheat potential growing areas to test the resistance of cultivars for disease in hot spot areas. Moreover, knowledge on the existing races is crucial as pathogens like Pgt are known to evolve their virulence frequently, there by compromising the durability of resistance [8, 9].

Race specific tests have not been conducted; hence, there is no data that shows which stem rust resistance genes are responsible for the resistance conferred in the cultivars. To get durable resistance gene against wheat stem rust requires constant characterization of the pathogen, and identification and deployment of new resistance genes that overcome the prevailing virulent races [10]. Reported that it is important testing wheat lines for response to multiple races of the stem rust pathogen to determine if lines possessed non-race-specific

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resistance. Testing of advanced breeding lines for *P. graminis f. sp.* tritici races can be breed cultivars with resistance gene deployment. Host plant resistance is the best management system which is economic and environmental safe. Wheat cultivars are released for production without carrying race specific tests against stem rust. Identification of genes and deployment of resistance gene in the advancement of varieties is economically important method of disease management. The objective was to evaluate durum wheat accessions Adult plant APR) against stem rust (*Puccinia graminis f.sp tritici*) races.

MATERIALS AND METHODS

Planting materials and sites: A total of 20 durum wheat landraces collections from highland of Chefe donsa, Gimbichu district were evaluated against stem rust (Table 1). The experiment was conducted at two locations at screening nursery and main research field soil not focused soil variation. The mixture of bread wheat cultivar Morocco, Digelu, and Arendato were used as susceptible check as well as spreader row which are known standard susceptible checks. The experiment was conducted following augmented design only checks were randomized. Recommended agronomic practices were applied to grow a healthy crop**.**

Pathogen materials: A mixture of TTRTF, TKTTF, TRTTF, TTTTF, TTKSK and JQCRC at equal proportion was used as inoculum source and inoculated in the field. The spreader row was inoculated by selected races to create artificial epidemics and facilitate infection by repeated spray of inoculations using Tween 20 detergent [11]. The spray inoculations were conducted in the afternoon after 5: 00 PM to facilitate infection and developmental during cold weather with high humidity. Data concerning to disease reactions was precisely recorded as per standard procedures. Details about the origin/pedigree of these genotypes are provided in (Table 1).

Physiological characterization of host studies on stem rust severity

The spray inoculations were conducted in the afternoon after 5: 00 PM in July to facilitate infection and developmental during cold weather with high humidity. The stem rust severity was recorded as percent of the rust infection on the wheat plants according to the modified Cobb's scale [12] and the host response scale to the infection type. The disease data were recorded by slow rusting parameters ACI, TRS, AUDPC [13] and DPR [14]. The data on disease severity and host reaction was combined to calculate the Coefficient of Infection (CI) by multiplying the severity value of 0.2, 0.4, 0.8, 1.0 for host response ratings R, MR, MS, S, respectively, [15].

Table 1. Host reactions in the field.

Reaction	Description	Mark	value
Resistant	Visible chlorosis/necrosis, no uredia are present	R	0.2
Moderately Resistant	Small uredia surrounded by chlorotic or necrotic areas	MR	0.4
Moderate	Mixture of small and mmedium sized pustules	M	0.6
Moderately Susceptible	Medium sized uredia with no necrotic margins with distinct chlorosis	MS	0.8
Susceptible	Large uredia and little or no chlorosis present.	S	1.0

RESULTS AND DISCUSSION

Average Coefficient of Infection (AIC)

The data on average coefficient of infection (ACI) recorded during main rainy season 2018/19. The stem rust severity and average coefficient of infection (ACI) of 20 genotypes is listed in the (Table 2). Susceptible checks have revealed moderately susceptible (MS) to susceptible (S) reaction of ACI values. Among tested 20 accessions such as accession 12, accession 1 and accession 2 has revealed resistance with value of 2.4, 2 and 4.8 at both locations while, accession 17 and accession 8 has revealed susceptible reaction for tested races (Table 2).

Table 2. Durum wheat accessions as evaluated by AIC parameter.

Accessions	Screening nursery		Black soil	
	Reaction	AIC	Reaction	AIC
Digelu (check)	S	16	MS-S	25.5
Arendato (check)	MS-S	18.6	MS-S	26.3
Morocco (check)	S	16	S	25.5
accession 16	MR/MS	6.4	MS	14
accession 5	MS	2.4	M/MS	14.75
accession 17	S	20	S	24
accession 18	MS	18	S	25
accession 4	MS	2.4	S	43.5
accession 19	MR	2	MS	12.75
accession 6	MS	5.6	S	33.5
accession 7	MR	4.8	MS	6
accession 8	S	19.4	S	28
accession 9	MR	2	MS	14
accession 10	MR-MS	4.4	MR-MS	8.75

accession 15	MS	5.6	M	11.25
accession 11	MS	12	MS-S	21
accession 12	MR	2.4	MR	6.75
accession 13	MR-MS	4.8	MS	12.75
accession 14	M/MS	3.4	MS	10
accession 20	MR	3.6	MS	17
accession 1	MR	2	MR/MS	9.5
accession 3	MS	4.8	S	36.5
accession 2	MR	4.8	MR	6.5

Final rust severity

Various host responses were also observed ranging from Resistance (R) to Susceptible (S) (Appendex Table 2). There was wide variation in the stem rust terminal rust severity ranging from 10 to 60%. The tested durum wheat cultivars were grouped in to three categories of resistance at nursery and black soil, which is high, moderate, and low level of partial resistance, having 1-30, 31-50% and above 50% respectively [16]. Based on comparison criteria accessions such as accession 5, accession 16, accession 4, accession 19, accession 6, accession 7, accession 9, accession 10, accession 15, accession 12, accession 13, accession 14, accession 20, accession 1, accession 3 and accession 2 have revealed final rust severity value between 1-30% grouped as high partial resistance; while four accessions as accession 17, accession 18, accession 8 and accession 11 has shown 31-50% grouped as moderately susceptible (Table 3). Evaluation of durum wheat varieties for their resistances is very important in integrated stem rust management and to provide relevant information [17].

Table 3. Durum wheat accessions as evaluated by FRS and AUDPC parameter.

Accession	**Final rust severity**				**AUDPC**	
	Screening nursery		**Black soil**		**Screening nursery**	**Black soil**
	Value	**Rxn**	**Value**	**Rxn**	**Value**	**Value**
Digelu	35	S	35	MS	792.2	1034.4
Arendato	45	Ms	50	S	723.4	1150
Morocco	60	S	40	S	778.1	982.4
accession 16	30	MS	30	MS	300	550
accession 5	10	MS	35	M	100	725
accession 17	40	S	40	MS	950	1000
accession 18	40	S	40	S	850	950
accession 4	10	MS	60	S	100	1500
accession 19	10	MS	25	MS	100	575
accession 6	20	MS	50	S	250	1300
accession 7	20	MS	20	M	300	300
Accession 8	45	S	40	S	775	1125
accession 9	10	MS	30	MS	100	550
accession 10	15	MS	20	MS	275	400
accession 15	20	MS	30	M	250	400
accession 11	40	MR	40	MS	750	875
accession 12	10	MR	25	M	100	325
accession 13	20	MS	30	MS	300	550
accession 14	10	MS	25	MS	200	375
accession 20	15	MR	30	MS	225	700
accession 1	10	MR	25	MR	200	575
accession 3	25	MS	50	S	975	1350
accession 2	25	MR	20	MR	475	400

Area under Disease Progress Curve (AUDPC)

Disease progress curve is a better indicator of disease expression over time [18]. Based on the AUDPC value the tested wheat cultivars categorized in to three groups; 1-30% as having highly resistance, 31-70% as moderately resistance and above 70% of the check was grouped as susceptible cultivars compared to susceptible checks. Accessions at both locations; accession 16, accession 19, accession 7, accession 9, accession 10, accession 15, accession 12, accession 13, accession 14, accession 20, accession 1 and accession 2 has less AUDPC values lower than other treatments and standard check (Table 2). Of these accessions; accessions 1, and accessions 2 showed Moderately Susceptible (MS) response and the rest showed Moderately Resistance (MR) responses. According to [19-21], genotypes with MS infection type and low AUDPC might carry genes conferring durable resistance. Partially resistant cultivars highly delay evolution of new virulent races of the pathogen because multiple point mutations are extremely rare in such circumstance.

Disease progress rate

Slow rusting resistance is characterized by a reduced rate of

epidemic development despite a compatible host pathogen interaction. The higher disease progress rate observed on the accessions 5, accessions 17, accessions 18, accessions 4, accessions 19, accessions 6, accessions 9, accessions 15, accessions 1 and accessions 2 has revealed higher disease progress rate other than standard checks and used cultivars at both locations (Table 4). Conversely; minimum disease progress rate were observed on accession 16, accession 7, accession 8, accession 10, accession 10, accession 11, accession 12, accession 13, accession 14 and accession 20 (Table 4). Hence, the actual infection rate for susceptible checks may be more but minimal green tissue was available. Although severity or the area under the disease progress curve was increasing, the rate of infection reduced as epidemic progressed because less healthy plant tissue was available for additional infections.

Table 4. Reaction durum accessions for disease progress rate (DPR).

Accession	DPR	
	Screening nursery	**Black soil**
Digelu	0.32	0.081
Arendato	0.35	0.082
Morocco	0.35	0.082
Landrace 16	0.375	0.094
accession 5	0.398	0.099
accession 17	0.419	0.105
accession 18	0.419	0.105
accession 4	0.500	0.125
accession 19	0.350	0.087
accession 6	0.460	0.115
accession 7	0.321	0.080
accession 8	0.254	0.063
accession 9	0.375	0.094
accession 10	0.321	0.080
accession 15	0.375	0.094
accession 11	0.254	0.063
accession 12	0.350	0.087
accession 13	0.240	0.094
accession 14	0.185	0.087
accession 20	0.254	0.052
accession 1	0.460	0.087
accession 3	0.321	0.115
accession 2	0.062	0.080

CONCLUSION

Twenty durum wheat collected accessions was gained from Debre Zeit Agricultural Research Centre (DZARC) and three susceptible standard checks were evaluated for slow rusting characters against stem rust races under natural field conditions. The evaluation for slow rusting character was based on AIC, TRS, AUDPC and disease progress rate. The accessions have showed varying level of disease reaction against stem rust under natural field at DZARC grouped by different category of accessions were identified. Among accessions such as accessions 17 and accessions 18 categorized as susceptible. Based on the study; it is important that continuously characterize and identification of resistance cultivars against newly evolving stem rust races which requires attention. Use of slow rusting accessions for breeding programs for variety improvement to replace the available and susceptible variety like accession 2, accession 16, accession 10, accession 1 and accession 2 have better resistance against stem rust and promising for variety improvement, and gene deployment. The available major and minor gene should be identified to know the specific resistance gene. These generate an opportunity to improve durum wheat variety and cultivars resistance against stem rust and future manipulation in wheat improvement program after confirmatory study. Anywhere local cultivated durum wheat accessions and cultivars are important to search the available gene for their resistance against the identified and newly evolving races is mandatory across all stem rust important areas.

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CONFLICT OF INTEREST

The author has not declared any conflict of interest on the paper.

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