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Evaluation of wheat cultivars for slow rusting resistance in Guji zone, Southern Oromia

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Evaluation of Eleven and local bread wheat cultivars evaluated for slow rusting resistance was conducted in Bore district of southern Oromia during the main cropping season of 2011 under natural epidemics at Bore Agricultural Research site. Field evaluation of slow rusting resistance was assessed through Incidence, disease severity (DS), AUDPC and rAUDPC. Results of mean comparison of final rust severity, AUDPC and rAUDPC indicating that the cultivars; PBW343, Kubsa, Hawi, local and Galema had highest final rust severity (FRS) and rAUDPC and susceptible infection (4) at the later growth stage. Shorima, Danda`a, Kakaba, ET13A2 and Digalu had moderately resistance to moderately susceptible infection type at later growth stage. However, disease development on this cultivar was very slow compared to the highly susceptible cultivars. That why these cultivars had low disease severity, low AUDPC and rAUDPC, that is, up to 70% of susceptible cultivars and they could have probably slow rusting resistance. Cultivar ETBW5496 had no any infection and thus selected as immune or resistance cultivar.

Key words: Slow rusting, rAUDPC, Oromia.

INTRODUCTION

Wheat (*Triticum aesvivum* L.) is one of the major cereal crop cultivated in Ethiopia. However, productivity of wheat in Ethiopia in general and southern Oromia in particular is very low. The low productivity is attributed to a number of factors including biotic (diseases, insects, and weeds), abiotic, and low adoption of new agricultural technologies. Among these factors, wheat stem rust, caused by Puccinia pers.f.sp.tritici Eriks and E.Henn, is one of the most destructive diseases of wheat worldwide in general and particular in Ethiopia. In Ethiopia wheat stem rust cause a complete annihilation of wheat crops over wide areas during epidemic years. Slow rusting resistance is one of the methods used for wheat stem rust management during the epidemic years. Since race-specific resistance may be overcomed through genetic shifts or new form of virulence in the pathogen population, durable resistance is of great interest to wheat breeders (Suenaga et al., 2001; Lal ahamed et al., 2004). Slow rusting wheat cultivars infected with *Puccinia graminis* exhibit longer latent period, low rate of disease

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development than the susceptible wheat cultivar even though they are infected by the rust disease under the same environmental condition and disease pressure. The latent period is one of the important component of slow rusting resistance. In Ethiopia little effort was made so far to evaluate slow rusting resistant under natural condition and slow rusting as specific management option was not fully understood. However, the present paper was therefore, designed to evaluate wheat cultivars/ lines for slow rusting. The study reports the finding of study which is carried out to assess the slow rusting of 13 bread cultivars/line.

The objective of the study is to evaluate bread wheat cultivars for their slow rusting resistance response under field condition at Bore

MATERIALS AND METHODS

Eleven released bread wheat cultivars were planted along with one local check for their slow rusting ability under bore field condition at Bore Agricultural Research Center (BARC). The experiment was laid out in randomized complete block design (RCBD) with three replications. A plot size of 2.5 m × 1.2 m and 20 cm between rows was used respectively. A universally susceptible variety (Morocco) was planted around the whole experimental area to ensure sufficient disease pressure and uniform inoculum load around the whole experimental work. No artificial inoculation was made for the experiment. Initial disease assessment was made immediately after 50% of disease symptom observed on local or susceptible cultivar (Appendix Table 1).

Disease data collections

The disease severity was recorded as percentage of leaf/ stem area covered by rust following modified Cobb's scale as developed by Peterson et al. (1948). According to this scale, at 100% disease severity, the actual leaf/stem area covered by rust pustules is 37%. Wheat stem rust severity was examined visually on the whole plants and recorded as the percentage of plant part (tissue) affected. Disease assessment was commenced at 96 days after sowing (DAS) on this day 50% of susceptible cultivar shows disease symptom and continued to 140 DAS (maturity) at interval of 10 days from pre- tagged 10 plants from each four center row each plot/cultivars per blocks. Disease incidence (DI) was computed as proportion of infected plant to the total number of plant in assessed from each cultivar and it calculated as follows:

$$DI = \frac{\textit{Number of diseased plant}}{\textit{Total number of plant assessed}} \times 100$$

Percent severity index (PSI) was used to convert the scaled based collected severity into percentage by using the formula developed by Wheeler (1969).

$$PSI = \frac{Sum\ of\ material\ rating}{Numbers\ of\ plant\ scored\ \times maximum\ score\ on\ the\ scale} \times 100$$

Disease progress rate ('r'): Transformed percent disease severity at different date of assessments was linearized by logistic (ln(Y/ (1-Y) (Vander Plank 1963). The model was selected based on the R square value. The linearized data were regressed over time to determine the disease progress rate of each cultivar.

Area under Disease Progress Curve (AUDPC): The area under disease progress curve (AUDPC) was calculated by using the formula suggested by Wilcoxson and kovmand. (1975).

$$AUDPC = \sum_{i=1}^{n} [(X_{i+1} + X_i / 2)] \times (t_{i+1} - t_i)$$

Where, Xi = the average coefficient of infection of i^{th} record; X_{i+1} = the average coefficient of infection of $i+1^{th}$ record and $t_{i+1}\_t_i$ = Number of days between the i^{th} record and $i+_1$ th record and n = number observations.

Relative Area under Disease progress curve (rAUDPC):

$$rAUDPC = \frac{\boldsymbol{AUDPC\ of\ cultivars}}{\boldsymbol{AUDPC\ of\ local\ or\ susceptible\ cultivar}} \times \mathbf{100}$$

Lesion length: lesion was measured randomly by centimeter from one edge of the lesion zone to the other. Five lesion per plant and 25 lesion per plot or cultivars were measure and the average was used for the analysis.

Infection type: Infection type was collected based on the original scale proposed by Stakman et al. (1962).

Data analysis

Data on wheat stem rust incidence, severity, and AUDPC and disease progress rate were subjected to analysis of variance by using the methods described by Gomez and Gomez (1984) using SAS computer soft ware. Mean separation was based on LSD at 5% level probability level. Square root transformation was done for the disease progress rate computation to minimize variation due to many zeros during the disease assessment.

RESULTS AND DISCUSSION

Stem rust incidence

Final disease incidence of cultivars showed that there was a highly significant variation among evaluated cultivar at ($p < 0.01$). However, no significance difference was observed for Danda`a, Hawi, Digalu, Kubsa, Galema, Galil, Local and PBW 343, but difference were significant for all the rest of the cultivars. At the later growth stage all cultivars were susceptible to the disease except ETBW 5496 and Shorima. This cultivars show a resistant reaction throughout the disease assessment. The onset of the disease was earlier for the Kubsa, PBW 343, Hawi and Galema. Delay onset was observed by Shorima (ETBW5483), Danda`a (Danphe #1), Kakaba (Picaflor #1), ET13A2 and Digalu (HAR 3116). This indicating that the evaluated cultivars were varies in their level of disease resistance and disease development. The disease incidence was ranging from 0% (for resistant cultivar), moderate for slow rusting and 100% (for highly susceptible) cultivars. Initial incidence seemed to have little or no effect on the final severity of the cultivars. For example, in this study the local cultivars had only 0% initial incidence at the first disease assessment (96 DAS). However, the highest final severity of 91.7% was recorded from this cultivar. On the other hand, variety

Galil, which had initial incidence of 13.33%, had final severity of 60.83% which was moderately resistance cultivars.

Rust severity

No cultivar showed hypersensitive reaction at field condition; however, very low level to high disease severity was recorded from the evaluated cultivars indicating high level of slow rusting resistance as compared to local check. Disease severity of cultivars was showed highly significant at (P< 0.01). The final stem rust severity was varying from 0 to 93.67% for ETBW5496 and local respectively. Digalu, ET13A2, Danda`a and Galil were not significantly different from each other.

Previous studies also showed that final disease severity is one of the parameter which can be used to measure the resistance levels along with other slow rusting parameters (Parlevliet and van Ommeren, 1975; Li et al., 2006).

Final disease severity up to 93.67 was recorded for local, followed by Hawi (92.67%), Kubsa 91.33%), PBW343 (90.17%) and Galema (79.667) were grouped as highly susceptible cultivar depend their severity and infection type, while ETBW5496 remain immune throughout the disease assessment. Based on final stem rust severity cultivars were grouped into three ranges, that is, 0-30, 31-70 and greater than 70%. Four cultivars among the evaluated cultivars (that is, Hawi, Kubsa, PBW343 and Galema) were having maximum final wheat stem rust severity more than 70% of the check. Two cultivars (ETBW5496 and Shorima) exhibited disease severity up to 30% of the check and were marked to be having better resistance. Five cultivars (Kakaba, Danda`a, Digalu, ET13A2 and Galil) displayed relative final disease severity up to 70% of check and marked to be moderately resistant. Final rust severity represents the cumulative result of all resistance factors during the progress of epidemic (Parlevliet and van Omeren, 1975). Previously, Herrera-Foessel et al*.* (2007) also used final rust severity as a parameter to assess slow rusting behavior of wheat breeding lines. And confirmed lower final rust severity value for durum lines exhibiting slow rusting resistance as compared to local check.

Similarly, Broers et al. (1996) and Ali et al. (2009) also carried out field assessment of partial resistance to yellow rust for ranking of lines. According to them resistance level based on disease severity along with other slow rusting resistance parameters, they found that resistance level ranged from very low to very high among the tested cultivars. ETBW5496 showed immune rust reaction throughout the disease assessment. This cultivar might have a combination of many major gene or minor genes which gives highest protection to wheat stem rust.

According to results of other researchers (Ali et al., 2007) lines which had resistance reaction at adult plant stage and low values of slow rusting parameters may probably carry major gene or combination of major genes based resistance, effective against all virulence used. The current studies corroborate results of those researchers.

Disease progress rate

Logistic model was used to describing the rate of stem rust infection. The coefficient of determination (R^2) was higher for logistic model. Based on logistic model, the regression equation used to describe the rate of wheat stem rust progress was not significant for all cultivars except for the susceptible cultivar apparently because of low disease development per unit day on slow rusting cultivars. The coefficient of determination (R2) was very low (<42%) for each plot of slow rusting cultivars. However, in most of susceptible cultivars the disease progress rate was significant at (P<0.05). Generally, variation in wheat stem rust infection rate due to the resistance level of the cultivar was clearly observed. Wheat stem rust was increasing more rapidly on susceptible plots than on slow rusting cultivars (Appendix Table 2).

Area under the disease progress curve

The PBW 343 reached highest AUDPC (1749% days) which was not significantly varied from Kubsa, Hawi and local but, significantly different from other susceptible cultivars.

Based on the relative AUDPC values, cultivars were categorized into two distinct groups that is, those exhibiting relative AUDPC values up to 30% of local and those showing relative AUDPC value up to 70% of local.

Six cultivars namely: ETBW5496, Shorima, Danda`a, Kakaba, Digalu and ET13A2 exhibited relative AUDPC values less than 30% of local and were marked to be having better level of slow rusting. Galil had a relative AUDPC values up to 70% of local check was grouped as moderately slow rusting. Five cultivars namely, Galema, Kubsa, Hawi, Local and PBW343 had a rAUDPC value greater than 70% of the local were classified as susceptible to highly susceptible.

Previously, Broers et al. (1996) has also evaluated wheat lines for their slow rusting ability through AUDPC and found that resistance levels ranged from very low (in Taichung 23) to very high (in Parula) among the tested lines. That why, the AUDPC and others parameters values were used as a classification criterion

The resistant cultivar in this study was found to be ETBW5496. This cultivar also gave medium yield, the lowest severity and lowest AUDPC throughout the disease assessments. From the evaluated cultivars

Shorima, ET13A2, Kakaba, Danda`a, and Digalu were good slow rusting as they had low disease severity and low AUDPC as compared to others while Galil were classified under moderately susceptible (Appendix Table 2).

SUMMARY AND CONCLUSION

Eleven bread wheat cultivars released by the Kulumsa Agricultural Research Center (KARC) and one local were evaluated for slow rusting against wheat stem rust under field conditions. The evaluations of slow rusting cultivars were based on AUDPC, rAUDPC, and final stem rust severity. These cultivars showed varying levels of resistance against wheat stem rust in natural conditions at Bore district of the Guji zone. Based on slow rusting parameters three groups of cultivar were identified. Namely PBW 343, Kubsa, Hawi, Local and Galema were classified as highly susceptible. However, ETBW5496 and Shorima showed better resistance cultivar. ET13A2, Danda`a, Kakaba, Digalu, and Galil were classified as moderately slow rusting. Highest yield was obtained from the slow rusting cultivars Digalu (7.39t/ha).

Based on these findings of the study, it can be concluded that wheat stem rust is an important disease that requires better attention in the area in terms of disease management. Use of slow rusting cultivars and replacing local and susceptible improved cultivar like Kubsa with slow rusting cultivars is important. ETBW5496 appears to have better resistance to the wheat stem rust and is a promising cultivar since the yield was also far better than the local. The results of current field experiment showed that the cultivars had diversity regarding resistance reaction, ranging from complete resistance to susceptible lines. This creates an opportunity for further improvement of resistance level of wheat cultivars and future manipulation in wheat improvement programs after confirmatory study. Finally in Guji as well as where ever wheat stem rust was existed planting of slow rusting cultivars is a simple solution for the management of the disease.

Conflict of Interest

The author(s) have not declared any conflict of interest.

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APPENDIX

Appendix Table 1. Description of bread wheat cultivars used for evaluation of slow rusting resistance.

No.	Cultivar	Pedigree	Year of release	Maturity (days)	Adaptation zone	Source center
1	Danda`a	Kiritati//2*PBW65/2*Seri.1B	2010	110-145	2000-2600	KARC/EIAR
2	ETB13A2	UQ105 Sel X ENKOY	2007	118-127	1890-2800	ADARC
3	Digelu	Sha 7 / Kauz	2005	100-120	2000-2600	KARC/EIAR
4	ETBW 5496	UTQE96/3/PYN/BAU//Milan	2011	NA	NA	ICARDA
5	Galema	4777(2)//FKN/GB/3/PVN	1995	NA	2200-2800	KARC/EIAR
6	Galil	NA	2010	NA	NA	Hezera genetic ltd
7	Hawi	CHIL/PRL	2000	105-125	1800-2200	KARC/EIAR
8	Kakaba	Kititati//Seri/Rayon	2010	90-120	1500-2200	KARC/EIAR
9	Kubsa	ATTILA	1995	NA	2000-2600	KARC/EIAR
10	Local	NA	NA	NA	NA	farmer
11	Shorima	UTQE96/3/PYN/BAU//Milan	2011	NA	NA	ICARDA
12	PBW343	NA				

KARC/EIAR = Kulumsa Agricultural Research Center/Ethiopian Institute of Agricultural Research; ADARC/ARARI = Adet Agricultural Research Center/Amhara Regional Agricultural Research Institute; NA = not available.

Appendix Table 2. Wheat stem rust disease incidence, severity, area under the disease progress curve, relative area under the disease progress curve of 13 bread wheat cultivar at Bore during main season of 2011.

Cultivar	% Incidence	%Severity	AUDPC	rAUDPC	LL (cm)	Dpr
Danda`a	83.33^{ab}	48.33^{bc}	190^{ef}	11.19	0.193^{e}	0.006
ETB13A2	46.00^{c}	48.00^{bc}	296.67^{de}	16.95	0.067^{e}	0.005
Digelu	90.00^{ab}	50.67^{bc}	317.17^{de}	18.68	0.360^{e}	0.006
ETBW 5496	0.00d	0.00^{e}	0.00^{f}	0.00	0.000^{e}	0.000
Galema	100.00^{a}	79.67^{a}	1504.67^{b}	85.99	1.413^{ab}	0.06
Galil	93.33^{ab}	55.16^{bc}	660.5^{c}	38.97	0.760^{d}	0.010
Hawi	100.00^{a}	92.67^{a}	1698.67^{a}	100.00	1.132^{bc}	0.090
Kakaba	70.00b^{c}	45.00^{c}	192.67^{ef}	11.35	0.117^{e}	0.008
Kubsa	100.00^{a}	91.33^{a}	1682.00^{ab}	99.10	1.530^{a}	0.101
Local	100.00^{a}	93.67^{a}	1697.2^{ab}	100.00	1.550^{a}	0.08
Shorima	1.50^{d}	7.00^{e}	29.25^{f}	9.85	0.000^{e}	0.004
PBW343	100.00^{a}	90.17^{a}	1749.8^{a}	103.09	1.367^{ab}	0.101
LSD(0.05)	26.124	14.16	197.95	-		0.006
CV (%)	20.34	14.25%	14.34		18.84	0.006
R2						89.77%

Means with the same letter are not significantly different from each other. Inc = incidence and AUDPC = Area under the disease progress curve; rAUDPC = relative area the under disease progress curve, average coefficient of infection; I = immune; MR = moderately resistance; MS = moderately susceptible; MSS = moderately susceptible to susceptible; S = susceptible; LL = lesion Length; DPr = disease progress rate.