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Yield variability of breadwheat under wheat stem rust pressure at bore field condition of Southern Oromia

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ABSTRACT

Eleven bread wheat cultivars were evaluated along with one susceptible local cultivar as control for field variation under wheat stem rust pressure during the main cropping season of 2011/12 at Bore Agricultural Research Station. The maximum wheat stem rust severity was recorded from the local cultivar (93.6%). Disease severity ranged from 0% for highly resistant cultivar (ETBW 5496) to 93.6% for susceptible cultivar. Cultivar with high disease severity and area under disease progress curve gave the lowest grain yield. Cultivars with low disease severity gave higher yield compared to the susceptible cultivars. Digalu gave higher mean grain yield (7.3 t ha^{-1}) followed by Danda`a (6.26 t ha^{-1}) with disease severity values of 56% and 48% respectively. Galema had higher disease pressure of 79% with lower mean grain yield of (1.15 t ha^{-1}). Shorima, Kakaba, ETBW13A2, and ETBW5496 had better yield and lower stem rust severity and were recommended for cultivation under moderate stem rust infestation.

Key words: wheat Stem Rust, yield variability, bore.

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INTRODUCTION

Wheat (*Triticum aestivum*) is one of the major crops cultivated in Ethiopia. However, productivity of wheat in Ethiopia in general and Guji zone in particular is very low. The low productivity is attributed to a number of factors including biotic (diseases, insects, and weeds), abiotic (low and high rainfall) and low adoption of new agricultural technologies. Among the biotic factors, wheat stem rust, also known as black rust, caused by the fungus *Puccinia graminis* f. sp. *tritici* has been the most devastating disease of all wheat rusts in Ethiopia causing up to complete annihilation of wheat crops over wide areas during epidemic years. This biotroph reduces the total photosynthetic area, utilizes plant's assimilates and interrupts the normal growth of the host leading to reduction of yield. The reduction in yield due to the disease may lead to severe economic losses to the farmers. The development and release of resistant cultivars is considered to be the only economic and environment safest way to control measure (Stubbs et al., 1986; Smale et al., 1998; Singh et al., 2004). The diversity in pathogen may vary considerably across regions and over the years (Stubbs 1985; de Vallavieille-Pope and Line 1990; Bayles et al., 2000; Shah et al., 2006). Similarly, a negative relationship between the yield

and yield components and disease severity has been reported (Allen et al., 1963; Ali et al., 2007), suggesting variability in yield was depending on extent of disease pressure. Little is known about the reaction of varieties and subsequent yields under black rust condition of Bore in Guji zone from Southern Ethiopia. The present study was designed to assess the yield potential of 11 bread wheat varieties under Bore field condition with special reference to wheat stem rust.

MATERIALS AND METHODS

Eleven wheat varieties released by Kulumsa Agriculture Research Center along with one susceptible control variety were grown at Bore Agriculture Research station during the main cropping season of 2011/12. Seeds of each entry were planted in strips of small adjacent plots consisting of 6 row-plots per plot, with a row length of 3 M separated by 1 M. The Morocco variety was sown around the whole experimental areas to create sufficient pathogen inoculum pressure. All the cultural practices like weeding and fertilizer application were applied uniformly to all the entries as per recommended. Disease scoring was made after 50% of wheat stem rust symptom appeared on the control. Disease severity was estimated from all the above ground parts of the wheat (stem, sheath and leaf). Estimates of disease severity were done according to Paterson et al., (1948), which is used to determine the percentage of possible tissue rusted and recorded as described in Appendix table. 1000-grain weight (g) and grain yield (kg ha-1) were calculated as described by Hassan (2004). Thousand grains from each cultivar were sampled using a seed counter and weighed on an electronic balance. The plot yield was expressed in tones per hectare. The analysis of variance for plant height (PHT), days to heading (DH), days to maturity (DM), number of seeds per spike (NSEPS), effective tillers or number of tillers per plant (ET or NTIPPI), yield per plot (Yld/plot), yield per ha (Yld/ha), thousand seed weight (TSW) and the comparison of their means values were performed as described by Gomez and Gomez (1984), using SAS software (SAS,2009 version 9.1). Correlation analysis was performed to determine the association of disease parameter with yield and yield component of wheat.

RESULTS AND DISCUSSIONS

Significant variations in yield and some agronomic characteristics were observed among the cultivars. The yield of the cultivars were significantly varied ($p<0.01$) with the highest of 7.39t/ha and the lowest of 1.15t/ha yield obtained from Digalu and Galema, respectively (Table 1). The number of days to maturity ranged from 149.7 day for cultivar PBW 343 and Kubsa, 171.7 day for Digalu. The highest effective tillers was observed by ETBW5496 (3 plant) and the lowest was recorded from (2.0 plant) from Kubsa.

TSW was significantly different among evaluated cultivars under field conditions. This might be due to difference in disease reaction of the evaluated cultivars. TSW was lower for susceptible cultivar particularly for the Galema and Kubsa.

The highest TSW was observed by Danda`a. TSW is an important component of yield mostly affected by stem rust. The reduction in TSW is due to the effect of the disease on the size and mass of the seed (shriveling of the kernels). Dill-Macky et al. (1990) reported up to 45% reduction in TSW was reported in Australia due to wheat stem rust.

The late appearance of wheat stem rust epidemic may signify the greater impact on grain filling and kernel weight. This is because in cereals, large amount of assimilates are accumulated in the stem at the later stage of crop growth during a short period. Infection of wheat stem and leaf sheaths by wheat stem rust affects the transport of assimilates to the developing kernel and results in shriveled kernel (Singh, 1998; Everts et al., 2001).

Association of Yield and Disease Parameters

Galema and Kubsa had a maximum relative disease severity and relative AUDPC value produce the least thousand seed weigh of 23.33 and 24.67g respectively. These two cultivars also produce kernel weight of 0.06467 and 0.0867g as well as minimum grain yield was recorded from these two cultivars (Table 2). Previously, Allan et al. (1963) have also report the impact of rust infection on grain yield losses. Even though, cultivar ETBW 5496 was resistant it has low TSW. This could be due to its lower genetic potential and not due to rust infection. Maximum grain yield per plot was produced by Digalu (1.477kg/plot) followed by Danda`a (1.311 kg/plot).

The yield and disease severity of wheat stem rust were significantly different and negatively correlated ($r = -0.711$). This shows that a negative relation when there is an increase in disease parameter there was a decrease in yield parameters and vice versa, the correlation was relatively strong indicating that severity had high negative impact on yield reduction. Yield and AUDPC were also highly significant and negatively correlated ($r = -0.87$) than that of yield and severity indicating that lower AUDPC implies higher yield (Table 2 and 3). Ochoa and Parlevliet (2007) also found that high correlation coefficient between AUDPC and yield losses. TSW was also negatively correlated with stem rust severity and AUDPC showing lower AUDPC implies high TSW. A very

Table 1. Agronomic parameters of 12 bread wheat cultivars at Bore in 2011.

Cultivars	DH	DM	PHT	ET	NSESP	Yld/plot	TSW	t/ha
Danda`a	86.00abcde	166.7abc	107.7b	2.980abc	55.87ab	1.311ab	43.33a	6.26ab
Digelu	91.00abc	171.7a	103.7bcd	3.03ab	67.30a	1.477a	37ab	7.39a
ETB13A2	84.67bcdef	165.abcd	95.03defg	3.033ab	32.30e	0.7843bcd	35abc	5.72ab
ETBW 5496	91.33ab	168.7ab	96.03cdefg	3.31a	51.33abcd	1.135abc	34.67abc	5.67ab
Galema	87.00abcd	154.3bcd	95.03defg	2.290bc	32.60e	0.2960d	23.33e	1.15d
Galil	79 def	154.7 bcd	78.67h	2.26bc	58.47ab	1.078abc	33bcd	5.39b
Hawi	78.33f	152.7cd	90.30g	2.648abc	32.30e	0.7307bcd	31bcde	3.65C
Kakaba	79.33ef	155.000bcd	100.3bcde	2.83abc	41.43bcde	1.155abc	39.33ab	5.78ab
Kubsa	82.67def	149.7d	91.00fg	2.00c	31.13e	0.6557cd	24.67de	3.28c
Local	92a	156.3bcd	123.7a	2.403bc	51.03abcd	0.7843bcd	26.67cde	2.25cd
Shorima	81.33def	163.7abcd	99.77bcdef	2.85abc	53.20abcd	1.204abc	38.67ab	6.02ab
PBW343	84.33cdef	149.7 d	92.93efg	2.013c	34.67de	0.6250cd	25.67e	3.13c
CV (%)	3.22	3.80	3.53	12.4	15.97	23.83	10.26	14.43
SE	1.574	3.48	2.003	0.3070	4.04	0.1342	1.96	392

PHT= plant height (cm), **DH**= days to heading, DM= days to maturity, **NSEPS**= number of seeds per spike, ET or **NTIPPI**= effective tillers or number of tillers per plant, **Yld/plot**= yield per plot, Yld/ha= yield per ha, **TSW**=thousand seed weight, Mean within a column followed by the same letter(s) within a column are not significantly different from each other.

Table 2. Wheat stem rust disease Incidence, Severity, Average coefficient of infection, Area under the disease progress curve, Relative area under the disease progress curve and Response of 13 bread wheat cultivar at Bore during main season of 2011/2112.

Cultivar	% incidence	% severity	ACI	AUDPC	rAUDPC	r	Response
Danda`a	83.33ab	48.33bc	19.33e	190ef	11.19	0.006	MR
Digelu	90.00ab	50.67bc	25.8de	317.17de	18.68	0.006	MR-MS
ETB13A2	46.00c	48.00bc	23.00d	296.67de	16.95	0.005	MR-MS
ETBW 5496	0.00d	0.00e	0.00f	0.00f	0.00	0.000	I
Galema	100.00a	79.67a	79.66b	1504.67b	85.99	0.060	S
Galil	93.33ab	55.16bc	40.47c	660.5c	38.97	0.010	MSS
Hawi	100.00a	92.67a	92.66a	1698.67a	100.00	0.090	S
Kakaba	70.00bc	45.00c	17.60e	192.67ef	11.35	0.008	MR
Kubsa	100.00a	91.33a	91.33ab	1682.00ab	99.10	0.101	S
Local	100.00a	93.67a	93.66a	1697.2ab	100.00	0.080	S
Shorima	1.50d	7.00e	2.80f	29.25f	9.85	0.004	MR
PBW343	100.00a	90.17a	90.16a	1749.8a	103.09	0.101	S
LSD(0.05)	26.124	14.16	8.75	197.95	-		-
CV(%)	20.34	14.25%	10.97%	14.34			-

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, **SS**= moderately Susceptible to Susceptible, **S**= susceptible.

strong positive correlation (r=0.911) was observed between percent severity and AUDPC indicating that cultivars which were severely infected showed higher AUDPC values.

This is well positively correlated and agreed with the results of other researchers on cereal-rust pathosystems (Shah et al., 2010; Sandoval-Islas et al., 2007; Safavi et al., 2012). AUDPC and Disease progress rates were also positively correlated and highly significant.

Simple Regression Analysis Yield, Thousand Seed Weight and Disease parameter

For yield of each cultivar the regression equation using single point model revealed that for every one percent increase in disease severity and AUDPC in result in a yield loss of 0.022 and 0.0022% t/ha respectively. R-Square value computed for susceptible cultivar revealed that 58.1% of the variation in yield was contributed by the disease in the form of AUDPC. Yield variation due to disease for Digelu, Danda`a, Shorima, Kakaba, ETB13A2 and ETBW5496 was not significant at ($P<0.05$) while the variation was significant for susceptible cultivars. For one percent increase in stem rust severity and area under disease progress resulted in a reduction yield of by 0.1215 and 0.0044 t/ha was occur. This means 5.68 times reductions that occur in as compared to for Digalu, Danda`a, Shorima, Kakaba, ETB13A2 and ETBW5496 under the same situation wheat stem rust pressure

Table 3. Correlation coefficient (r) between yield and disease parameters of wheat cultivars evaluated for slow rusting resistance at Bore during main season of 2011.

Yld	TSW	Sev	AUDPC	NS
TSW	0.891***	_	_	_
Sev	-0.711***	-0.685***	-	_
AUDP	-0.876***	-0.878 ***	0.911***	_
Rate	-0.817***	-0.835***	0.846***	0.968***

Yld = yield; **TSW**= Thousand Seed weight; **Sev**= Severity; **AUDPC**=Area Under disease progress curve. **NS**= Non-significant, *=Significant **= highly Significant, *** = very highly significant, All this were computed from the final disease assessment at 140DAS.

SUMMARY AND CONCLUSIONS

Eleven bread wheat cultivars released by the Kulumsa Agricultural Research Center (KARC) and one local were evaluated for their yield variability under field condition of wheat stem rust pressure at Bore district of southern Ethiopia.

Variability among varieties may be attributed due to the diverse genetic background of these varieties with different pedigrees. Cultivars like, PBW 343, Kubsa, Hawi, Local and Galema were classified as highly susceptible and gives low yield as compared to other tested cultivars. ET13A2, Danda`a, Kakaba, Digalu, and Shorima show low disease severity compared to those susceptible cultivars while, Digalu gave the highest yield of 7.39t/ha under the same disease pressure in the tested site. Statistical analysis of the data revealed that disease severity had varying effect on yield and yield components. Yield potential is generally assessed through grain yield and yield components, which themselves are complex characters and are considered to be the cumulative result of different physiologic processes. Grains per spike (Shah et al. 2007; Fonseca and Patterson 1968) and grain weight (Tammam et al. 2000) are considered to be important yield contributing traits. The results of current field experiment study showed that the cultivars had diversity regarding resistance reaction, ranging from complete resistance to highly susceptible cultivars which resulted in difference in yield potential of the cultivars. It was effective, safe, environmentally sound, affordable, and sustainable strategies to manage wheat rust diseases by growing Digalu, Danda`a, Shorima, Kakaba, ETB13A2 and ETB5496 were moderate epidemic of wheat stem rust was happened. Finally in Guji as well as where ever stem rust was existed planting of slow rusting cultivars is a good solution for the management of the disease if such cultivars have been introduced because of breeding for disease resistance.

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Appendix 1.

Disease severity recording procedure depending on the actual percentage of the surface covered by lesion (A) and visual percentage described by Peterson et al., 1948.

A	B
0.37	1
1.85	5
3.7	10
7.4	20
11.1	30
14.8	40
18.5	50
22.2	60
25.9	70
29.5	80
33.3	90
37	100