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Selection of Bread Wheat Genotypes from Semi-Arid Wheat Yield Trial for Wheat Breeding Program Pipeline in Ethiopia

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Abstract: Wheat breeding mainly deals with the creation of variation through crossing; selection from consequent generation based on the traits of interest; and phenotypically fixation of traits to develop noble varieties for the farmers. The research center objectively doing, to improve the livelihood of the farmers through delivering high yield, disease resistance, and good quality bread wheat varieties with sufficient quality foundation seeds. The National Wheat Research Program introduced 28th Semi-Arid Wheat Yield Trial (28th SAWYT) along with other trials from CIMMYT Mexico. The introduced trial SAWYT had forty-nine genotypes and one empty room for the local check. A local check Kingbird added to the forty-nine genotypes, a total of 50 genotypes planted as SAWYT. The trial was conducted in Alpha Lattice design with two replications. The experiment was carried out at two locations: Kulumsa Agricultural Research Center (KARC) and Melkasa Agricultural Research Center (MARC). Date of Heading (DTH), Date of Maturity (DTM), Plant Height (PHT), and Disease data collected on the field on time. Thousand kernel weight (TKW), Hectoliter weight (HLW), and Grain Yield (GYLD) taken in the laboratory after harvest. Only two genotypes were significantly different at ($p < 0.05$) from the check variety kingbird for grain yield. Compared to the check, Kingbird, thirty-four genotypes showed better resistance to yellow rust disease (Table 2). Eleven genotypes exhibited better resistance for stem rust than Kingbird (Table 2). Moreover, EBW212106, EBW213073, EBW213074, EBW213077, EBW212110, EBW213087, EBW213106, and EBW213107 revealed resistance for both of wheat rusts than Kingbird. Testing genotype in the right environment enables the breeders to develop and release best bread wheat varieties for the farmers.

Keywords: Wheat, SAWYT, Kingbird, CIMMYT

1. Introduction

Wheat is one of the sources of carbohydrates for people in the world. Its production in the world in 2021/22 reached about 780 million metric tons [2]. Population growth, increment of urbanization, and the ability to make unique food products increase global demand for wheat. The gluten protein found in the crop allows producing bread, other baked products, and pasta.

Wheat breeding mainly deals with the creation of variation through crossing; selection from consequent generation based on the traits of interest; and phenotypically fixation of traits to develop noble varieties for the farmers. It is a science that is targeted to improve the yield and quality of wheat for users [1].

Production and productivity of wheat in Ethiopia are largely threatened by fungal wheat rusts. Wheat stem rust and wheat stripe rust are the major biotic constraints to wheat production in Ethiopia. The country is a hotspot area for stem rust and yellow rust [3]. In an epidemic year, they cause huge economic losses. The major wheat stripe rust epidemic in 2010 seriously damage popular adapted varieties: Kubsa and Galema. It affected more than 600000ha of wheat growing areas and reduced up to 20% production [5, 6]. In the 2013-2014 cropping season, a popular variety Digelue, which covers about 30-40% of areas in main wheat-producing areas severely affected by race TKTTF or Digelu race. Due to this stem race outbreak, up to 92%, maximum yield loss, and average losses of approximately 50% were recorded [4]. Even though Productivity reduced by many constraints, Ethiopia is the highest wheat producing countries in sub Saharan Africa. With area coverage of 1.6-1.8 million hectares of land, the country produced about 1.8 million tons of wheat in 2021. This put the country 1st in sub-Saharan Africa and 2nd in Africa [13-15].

The National and other wheat breeding programs in Ethiopia mainly work on developing and releasing bread wheat varieties resistant to wheat rust diseases. In addition to their crossing blocks, they introduce germplasm from main partners: CIMMYT and ICARDA which they objectively crossed for these devastating wheat rusts. The National Wheat Research Program, Kulumsa Agricultural Research Center tests materials for different wheat diseases and different wheat-producing environments. The research center objectively doing, to contribute to the improvement the livelihood of the small holder farmers through delivering high yield, disease resistance, and good quality bread wheat varieties with sufficient quality foundation seeds.

2. Material Method

2.1. Study Materials, Design, and Description of Study Area

The National Wheat Research Program introduced 28 th Semi-Arid Wheat Yield Trial (28 th SAWYT) along with other trials from CIMMYT Mexico. The introduced trial SAWYT had forty-nine genotypes and one empty room for the local check. A local check Kingbird added to the forty-nine genotypes, a total of 50 genotypes planted as SAWYT. The check Kingbird is a bread wheat variety released in Ethiopia in 2015. It is a widely adapted popular variety in low lands of the country.

The trial was conducted in Alpha Lattice design with two replications. A rep had five sub-blocks. Each subblock had 10 plots. In general, the trial had a total of one hundred plots. A plot of 2.5m in length by 1.2m in width was used with a total area of $3m^2$. Distances between Reps and Blocks were 1.5m and 1m respectively. Urea and NPS fertilizers were applied as per recommendation for the areas.

The experiment was carried out at two locations: Kulumsa Agricultural Research Center (KARC) and Melkasa Agricultural Research Center (MARC). Kulumsa Agricultural Research Center was found at 8°02′N 39°10′E latitude and longitude with an Altitude of 2200 m.a.s.l; Melkasa Agricultural Research Center found at at 8°24′N 39°12′E latitude and longitude with an Altitude of 550 m.a.s.l.

2.2. Data Collection and Analysis

Date of Heading (DTH), Date of Maturity (DTM), Plant Height (PHT), and Disease data collected on the field on time. Thousand kernel weight (TKW), Hectoliter weight (HLW), and Grain Yield (GYLD) taken in the laboratory after harvest. All data were electronically captured and transferred in to the National Wheat Research Program Server at KARK, where, later processed and used for analysis.

Stem Rust (SR) and Yellow Rust (YR) were taken on the field two times. The first score was taken just a few days after the symptom of the disease appeared on the experimental plots. The second round score, the final score taken while the progress of the diseases reached its maximum level.

The wheat rust disease score was a combination of severity and reaction. The modified cobb scale was used to score stem rust and yellow rust [7, 8].

Severity is the percentage of rust infection on the plant taken in percent;

Severity scale= 5%, 10%,………multiple of 5 up to 100%

Reaction is the plant response for the pathogen; Letters in English alphabet used to score the reaction.

The letters used to score the rust reaction are:

0= no visible infection on the plant,

R= resistance: visible chlorosis or necrosis with the absence of uredia,

MR= moderately resistance: small uredia are present and surrounded by either chlorotic or necrotic area,

M= Intermediate: variable sized uredia are present some with chlorotic, necrosis, or both,

MS= moderately susceptible: Medium size uredia are present and possible surrounded by chlorotic areas,

S= Susceptible: Large uredia present, generally with little or no chlorosis and no necrosis.

The letters used to score the reaction are converted to Numbers between 0 and 1 which are later used to calculate the coefficient of infection (CI). The values are: (O) = 0.05, resistance (R) =0.1, moderately resistant (MR) = 0.2, intermediate (M) = 0.4, moderately susceptible (MS) =0.6, and susceptible (S) = 1. The coefficient of infection is calculated by multiplying the value of the reaction with the value of severity using the values outlined by [9].

The data of both wheat rusts were collected with a modified cobb scale, severity with present and reaction with letters then, converted to Coefficient of Infection for the analysis and selection.

The analysis of variance, ANOVA is computed to compare the variance related to genotypes to that of variance environmentally occurring between plots [11].

To compare the means of the yield between different genotypes and the check, the Least significant difference between LSD was calculated using the method outlined by [12].

Least Significant Difference (LSD):

$$LSD_{A.B=}t_{0.05/2DFW}\sqrt{(MSW(1/nA + 1/nB))}$$

Where:

t = critical value from the t- distribution table,

MSw =Mean square, obtained from the results of ANOVA test,

n = number of scores used to calculate the means.

All data’s in the study computed using R-software version 3.6.0 [13].

3. Result and Discussion

The national wheat research program has two germplasm sources for the yield trials pipeline. The first is its crossing blocks. The breeding program crosses two times a year among varieties and promising lines. The second source for germplasm is Introduction mainly from CIMMYT and ICARDA.

The program selects genotypes from the F6 generation from its crossing blocks and from Introduction trials based on the performance they exhibited. Then, the selected genotypes were put into Observation Nursery Trial for different Agroecology. The wheat research program grouped the whole wheat-producing agroecology of the country but irrigation into three product concepts: Low lands, midlands, and highlands. From the Observation Nursery Trial (OBT) to Variety Verification Trial (VVT) set based on this concept. Genotypes selected from this study advance into Observation Nursery Trial for low wheat-producing areas.

In experimental plots, variance arises from different sources. It is difficult for researchers to differentiate whether the variance sources are from genotypes or not. ANOVA split the variances into discrete variances that are associated with the treatments. Also, Analysis of variance, ANOVA helps to identify the existence of significant differences among the genotypes for the tested traits.

The ANOVA table showed the existence high significant difference among tested genotypes for all traits. Additionally, the value for the mean square of error for yield is low (Table 2). This showed that the assumption for the existence of differences in yield rises from the true performance of genotypes. Therefore, selections among these genotypes were effective. The value of variance for location is higher compared to other sources of variation. This is because of the agro ecological differences between the testing sites.

Table 1. *Genotype (G), environment (E), and GXE me/ans squares for grain yield (GYLD), date of heading (DTH), date of maturity (DTM), Plant height (PHT), thousand kernel weight (TKW), and hectoliter weight (HLW), Yelow rust (YR), Stem Rust (SR) of fifty bread wheat genotypes tested at two locations.*

Source of variation	DF	DTH	DTM	PHT	YR	SR	TKW	HLW	GYLD
Rep	1	2.9ns	3ns	248.6**	122.6ns	6.7ns	19.2ns	0.3121ns	9.12***
Genotype (G)	49	28.0***	224***	44.4**	264.4***	386.1***	44.17***	27.185***	2.67***
Location (E)	1	14518.1***	54186***	9786***	11861.1***	26666.6***	0.018ns	107.02***	120.19***
Geno: Loc (GXE)	49	7.5*	9***	29.7ns	264.4***	235.6***	41.4***	24.982***	3.3***
Residual	99	4.6	2	23.3	35.2	139.4	11.26	4.55	0.56

ns=non-significant; *,**, and *** significant 5%, 1%, and 0.1% level of significance, consecutively.

Table 2. *Mean value of eight traits and least significant difference of yield of twenty bread wheat genotypes tested across two locations in Ethiopia.*

Entry	Genotype	DTH	DTM	PHT	YR (CI)	SR (CI)	TKW	HLW	YLD
301	KINGBIRD	64	109	85.75	16.5	4	28	66.02	3.46
302	EBW212687	61.5	110	87	2	22	37	69.2	4.95
303	EBW212688	59.75	106.75	91.25	4.5	31.5	34.5	58.26	4.16
304	EBW212689	54.5	108	79.25	8	27.65	28.5	62.57	3.98
305	EBW212001	61	105.75	85.25	45	1	28.5	60.96	3.35
306	EBW213069	61.5	109.25	87.75	5	11.5	30.5	63.68	4.41
307	EBW213070	63	108	86.25	37	3	27	63.17	3.73
308	EBW213071	57.25	108	81.25	10.5	3.65	32.5	68.27	4.77
309	EBW213072	62	107.75	89.5	6.5	9.1	35	65.61	5.56
310	EBW212106	63	108.5	85.25	0.5	1.55	35.5	65.23	5.65
311	EBW213073	62.5	109.25	88	0.2	3	34	67.23	4.27
312	EBW213074	63	106.25	83.25	9	3	32	66.51	4.82
313	EBW213075	65.75	109.75	85.75	0.3	11.25	31	63.85	5.15
314	EBW213076	60.75	107.5	81.75	15	13	32	65.03	3.92
315	EBW213077	63	108.25	86.5	2	3.65	34	68.62	4.51
316	EBW213078	67.5	109.5	81.5	18	9	29.5	64.54	3.94
317	EBW213079	59.25	108	81.25	15.5	11.5	29.5	60.58	3.23
318	EBW213080	63.75	108.75	87.5	5.5	9.15	36.5	66.58	3.98
319	EBW213081	62.25	109	84.75	5.5	19	34	69.54	5.59
320	EBW213082	65.25	108.5	88	45	15.75	29	66.5	3.39
321	EBW213083	62	105.5	88.5	12	22	32.5	66.23	4.49
322	EBW213084	61.5	107.5	86	29	21.25	29.5	63.31	3.34
323	EBW213085	60	107.25	83.75	50	22.5	30.5	66.12	3.18
324	EBW213086	60	109	84.5	1.5	16.25	32.5	67.52	5.06
325	EBW212110	5.28	107	80	12	2.55	32.5	64.03	5.28
326	EBW213087	66.75	109	86.75	9	3	34	66.6	5.28
327	EBW212112	59.5	107.5	84	4	39	31	64.09	4.14
328	EBW213088	62	107.5	88.25	10.5	23.25	31	66.89	4.36
329	EBW213089	62.25	108.75	90	34	9	31.5	62.97	3.18
330	EBW213090	63	107.5	83.75	29	20	28.5	63.25	3.61
331	EBW213091	59.75	108.5	85.25	9	12.25	32.5	66.86	4.89
332	EBW213092	63	108.5	85.5	9	6.25	35	66.56	4.42

Entry	Genotype	DTH	DTM	PHT	YR (CI)	SR (CI)	TKW	HLW	YLD
333	EBW213093	66	106.5	81.25	16.5	32.5	30	64.18	3.89
334	EBW213094	58.25	107.5	74.25	13.5	18	29.5	62.64	3.6
335	EBW213095	66.75	108.5	86.25	50	17.5	22.5	59.81	2.62
336	EBW213096	62.75	109.25	80.5	65	20	22	59.62	1.97
337	EBW213097	62	109.25	78.25	45	20	27	59.85	2.37
338	EBW212017	59	107.25	84.75	22	21.5	29.5	63.25	3.45
339	EBW213098	61	109	86.25	1.1	27.8	34.5	67.34	4.45
340	EBW213099	62	108.5	89	0.3	36.75	33.5	68.63	4.69
341	EBW213100	64	109	85.5	0.2	14.5	32	68.1	4.69
342	EBW213101	65.75	110.25	86.25	1	19.75	33.5	65.98	5.04
343	EBW213102	63.5	109.75	83.25	1.5	15.9	31.5	66.23	4.38
344	EBW213103	55.25	109.5	81.25	4	4.5	33	66.02	4.02
345	EBW212138	61.5	109	83.75	4	24.15	39.5	66.92	4.97
346	EBW213104	61.5	108	78.75	16.5	24.15	30.5	64.02	3.34
347	EBW213105	60	108.25	82	40	20.15	30	63.93	3.06
348	EBW213106	63.5	108.25	81.5	8.5	2.65	34	64.49	4.1
349	EBW213107	63.25	107.25	85	6.5	3	28.5	66.09	3.9
350	EBW213108	62.75	107.5	87	15	10.5	30.5	65.46	4.41
Mean		60.89	108.24	84.56	15.42	14.88	31.42	64.98	4.14
LSD									2.12
CV									17.93
MSE									2.67

ETBW +number = Ethiopian bread wheat; and the number is a unique accession number given for individual genotypes by the national wheat research program.

Only two genotypes were significantly different at ($p<0.05$) from the check variety kingbird for grain yield. The mean grain yield of the check Kingbird was 3.46, and that of EBW212106 and EBW213081 were 5.65 and 5.59. The difference between the check and EBW212106 was 2.19, and the check and EBW213081 were 2.13. Both values were higher than the LSD 2.12. Therefore, EBW212106 and EBW213081 were significantly different from Kingbird at $p<0.05$ for grain yield (Table 2).

Although only two genotypes were significantly different from the check kingbird at $p<0.05$, others showed considerably higher yield than the check. Eight genotypes: EBW212687, EBW213071, EBW213074, EBW213077, EBW213083, EBW213091, EBW213099, and EBW213100 showed greater than one tone of higher yield than the check (Table 2). Moreover, Seven genotypes: EBW213072, EBW213075, EBW213086, EBW212110, EBW213087, EBW213101, and EBW212138 had greater than 1.5 tons higher yield than the check. Thus, if their performance for wheat rust disease and other traits were good it is important to advance and include them in the next stage of the breeding pipeline.

The two wheat rusts: Stem rust and Yellow rust are the major biotic constraint in wheat production in Ethiopia. In the epidemic year, stem rust causes up to 100% yield loss; up to 90% yield loss is recorded on an unsprayed experimental plot [10]. Hence, disease resistance is the key selection trait in the wheat breeding program in the country.

The lower values of the coefficient of infection (CI) mean the genotype is more resistant to that wheat rust. Compared to the check, Kingbird, thirty-four genotypes showed better resistance to yellow rust disease (Table 2). EBW212001, EBW213070, EBW213071, EBW212106, EBW213073, EBW213074, EBW213077, EBW212110, EBW213087, EBW213106, and EBW213107 exhibited better resistance for stem rust than Kingbird (Table 2). Furthermore, EBW212106, EBW213073, EBW213074, EBW213077, EBW212110, EBW213087, EBW213106, and EBW213107 revealed resistance for both of wheat rusts than Kingbird.

4. Conclusion

Wheat production and productivity are largely affected by wheat rust in Ethiopia. Thus, Rust disease resistance is among the determinant factor for selection in the breeding program. Yellow rust does not cause a serious problem in lowland areas. Therefore, it is better to advance genotypes: with entry number 302, 308, 309, 310, 312, 313, 315, 321, 324, 325, 326, 331, 340, 341, 342, 345 to advance trial set for low land area. Because these genotypes perform better in yellow rust and yield than the Check. On the other hand, Stem rust is a problem from low land to high altitudes. Hence, it is good to put these genotypes: 308, 310, 312, 315, 325, and 326 in to advance trial set for low land and mid-altitude. Generally, testing genotype in the right environment enables the breeders to develop and release noble bread wheat varieties for the farmers.

Conflict of Interest

All the authors do not have any possible conflicts of interest.

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References

[1] Crop breeding. (n.d.) *Collins Dictionary of Biology, 3rd ed.* (2005). Retrieved May 9 2022 from https://medical-dictionary.thefreedictionary.com/Crop+breeding

[2] M. Shahbandeh. Global wheat production from 2011/2012 to 2021/2022 (in million metric tons) Statista (2022). Retrieved from www.statista.com/statistics/267268/production-of-wheat-worldwide-since-1990/

[3] D. Singh, B. Girma, P. Njau, R. Wanyera, A. Badebo, S. Bhavani, R. P. Singh, J. Huerta-Espino, G. Woldeab, R. Ward. Screening for stem rust in East Africa. Oral papers 2009 Technical workshop. P 111-115.

[4] Olivera Firpo PD, Newcomb M, Szabo LJ, Rouse MN, Johnson JL, Gale SW, et al. Phenotypic and genotypic characterization of race TKTTF of Puccinia graminis f. sp. tritici that caused a wheat stem rust epidemic in southern Ethiopia in 2013/2014. Phytopathology. 2015; 105: 917–928. pmid: 25775107.

[5] Sanders R. Strategies to reduce the emerging wheat stripe rust disease. Synthesis of a dialog between policy makers and scientists from 31 countries at: international wheat stripe rust symposium. Aleppo, Syria: International Center for Agricultural Research in the Dry Areas (ICARDA); 2011.

[6] David Hudson. Rust Tracker. Org (2010). Ethiopian Rust survey summary Serious yellow rust epidemic. Retrieved on 10 May 2022, 2022 from https://rusttracker.cimmyt.org/?p=3725

[7] J. R. Stavely. The Modified Cobb Scale for Estimating Bean Rust Intensity. USDA, ARS, Beltsville Agricultural Research Center-West Beltsville, MD 20705.

[8] Peterson, R. F., Campbell, A. G., and Hannah, A. E. 1948. A diagrammatic scale for estimating rust intensity on leaves and stems of cereals. Can. J. Res., Sec. C, 26: 496-500.

[9] Roelfs AP, Singh RP, Saari EE (1992). The Wheat rust. In Rust diseases of wheat: Concepts and methods of disease management, pp. 2-6. Mexico, D. F: CIMMYT.

[10] Alemu Ayele, Getnet Muche. Yield Loss Assessment in Bread Wheat Varieties Caused by Yellow Rust (Puccinia striiformis f. sp. tritici) in Arsi Highlands of South Eastern Ethiopia. American Journal of BioScience. Vol. 7, No. 6, 2019, pp. 104-112. doi: 10.11648/j.ajbio.20190706.14.

[11] Moore, K., R. Mowers, M. L. Harbur, and L. Merrick. 2016. The Analysis of Variance (ANOVA). *In* Quantitative Methods, interactive e-learning courseware. Plant Breeding E-Learning in Africa. Retrieved from https://pbea.agron.iastate.edu.

[12] Stephanie Glen "How to Calculate the Least Significant Difference (LSD)" From StatisticsHowTo.com: Elementary Statistics for the rest of us! https://www.statisticshowto.com/how-to-calculate-the-least-significant-difference-lsd/

[13] R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

[14] Bezawit Yilma (2022). An overview of wheat productivity, import value and consumption in Ethiopia. Global Scientific journals. Volume 10, issue 3 pp 815-823.

[15] Electronic, World population review. (2022). Wheat production by country. Retrieved 10 May 2022 A, from https://worldpopulationreview.com/country-rankings/wheat-production-by-country