Registration of a new Triticale Variety: '*Kombolcha*'

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Abstract

Background: Triticale (X-Triticosecale Wittmack) is a hybrid of wheat (*Triticum* sp.) and rye (*Secale* sp.) It combines yield potential and grain quality of wheat with the diseases and environmental tolerance including adaptability to marginal soils, diseases resistance and low-input requirements of rye. The crop has demonstrated high yield potential under marginal growing conditions and could a very attractive alternative for raising cereal production in the globe, involves Ethiopia.

Objective: To evaluate and release stable high yielding and disease resistant/tolerant Triticale variety for the western highland of Oromia and other similar agro-ecologies

Material and Methods: Twelve triticale genotypes including the standard check "Moti" were evaluated across two locations for three years (2015-2017). Eventually, two promising genotypes, "Acc 2012 MS #51 and Acc.2012 MS #59" were selected and promoted to variety verification trail with the standard check "Moti" during the 2018/19 cropping season. The national variety release technical committee evaluated the two candidate varieties both at Gedo and Shambu on research stations and farmers' fields.

Results: Among the two evaluated varieties, 'Kombolcha' is well adapted to altitudes ranging between 2244 and 2784 meters above sea level and characterized by amber seed color, longer panicle and gave high seed yield (6184.8 kg ha^{-1}) and stable performance across years and locations. It has about 13% yield advantage over the standard check variety, *"Moti"*. The variety is also resistant to major diseases such as steam rust (*Pucinia graminis* f.sp. *tritici*), yellow rust (*Puccinia striiformis* f.sp. *tritici*) and Septoria tritici (*Mycosphaerella graminicola*).

Conclusions: "Kombolcha" (Acc. 2012 MS #51) is released for the highlands of western Oromia and similar agro-ecologies for its stable and high grain yield, and resistant to major diseases. Therefore, farmers in western highlands of Oromia and similar agro ecologies particularly those inhabiting marginal and acid prone areas can produce "Kombolcha" variety with its full management recommendation.

Keywords: Disease resistance; Genotype; Grain yield; Moti; Triticosecale Wittmack; Yield stability

1. Introduction

Triticale (Triticosecale Wittmack, 2n = 6x = 42; BBAARR.) is a hybrid of wheat (*Triticum* sp.) and rye (*Secale* sp.) which was developed by using conventional plant breeding methods followed by embryo culture (Guedes-Pinto *et al*., 2001). Wheat was used as the maternal plant and rye was used as the paternal plant. Triticale obtained the best characteristics of the two crops. Wheat is characterized by high yield and better grain quality (Meng, 2009). But rye has greater diseases resistance and better tolerance to environmental stress (Crespo-Herrera *et al*., 2017). Triticale has high feeding value and superior adaptation to stress conditions such as drought, acidic soils, excess moisture and low soil fertility where other crops produce low yields and/or are poorly adapted (FAO, 2004). Triticale has a more vigorous root system than wheat, barley or oats. Its roots bind light soils and extract more nutrients from the soil. The vigorous root system of Triticale make growing this plant attractive soils with low fertility status particularly light-textured where crops are required to outcompete weeds for growth resources (Gobeze *et al*., 2007). Triticale has demonstrated high yield potential even under stress environmental conditions in Ethiopia and could be a very attractive alternative for increasing cereal production in the country. It was reported that Triticale increased farmers' net benefits compared to wheat and barley in Farta District of Amhara Regional State in Ethiopia (Mesfin, 2012).

In Ethiopia, the grain of triticale is used for human food, while the straw is used for animal feed, roof thatching, and as bedding material. In certain areas with marginal and acidic soils in the country in general and western Ethiopia in particular, triticale is one of the most promising newly introduced crop species that could show superior adaption.

Research results in areas with acidic and marginal soils of western Ethiopia have shown that triticale can be an excellent alternative crop to wheat and barley (BakoARC, 2019). There is no report in Ethiopia that indicates area coverage and production of triticale

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anywhere in the country. However, there have been already improved triticale varieties developed and released for production in different agro ecologists in the country. In the last few decades, Bako Agricultural Research Center developed and released two improved triticale varieties (Abdissa and Moti), which are adapted to marginal and acidic soil areas to which other crops are poorly adapted and produce low yields. In food-insecure countries like Ethiopia, climate change is expected to reduce yields through increased biotic and abiotic stresses. Concerns about such effects have prompted widespread efforts to identify varieties that may provide genetic variability for adaptation to climate change. Recently, the third variety, '*Kombolcha'* has been released, which is well-adapted in the wide agro-ecology of western Ethiopia and other areas with similar agro-ecology of Ethiopia.

2. Varietal Origin and Evaluation

Kombolcha (Acc 2012 MS #51) along with 11 genotypes were obtained from Debreziet Agriculture Research Center of the Ethiopian Institute of Agriculture Research. The genotypes were evaluated along with the standard check variety, "*Moti*", across two locations (Shambu and Gedo) from 2015-2017. Two genotypes "Acc 2012 MS #51 and Acc.2012 MS #59" were selected as candidate varieties based on a combined data analysis of variance and mean performances comparison of genotypes. The two most promising candidate varieties and the standard check variety, "*Moti*", were eventually promoted to a variety verification trial. The candidate varieties and standard check variety were planted in plots with a size of 10 m x 10 and evaluated by the national variety release technical committee at two locations during the 2018/19 cropping season. Finally, the national variety release technical committee selected "Acc 2012 MS #51" genotype for release. Acc 2012 MS #51 has high biomass, long panicle length, better yield advantage, and good resistance to major diseases like steam rust (*Pucinia graminis* f.sp. *tritici*), yellow rust (*Puccinia striiformis* f.sp. tritici) and Septoria tritici (*Mycosphaerella graminicola*).

3. Varietal Characteristics

Kombolcha variety significantly out-yielded Moti (the standard check variety) and the other candidate (Acc. 2012 MS #59) in terms of number of productive tillers, biological yield, and 1000 seeds weight. The new variety has 6.12%, 11.96%, and 12.74% longer panicles, heavier 1000 seed weight, and higher biological yield than *Moti* (the standard check variety), respectively (Table 1).

Number of spikes per unit area, 1000-grain weight, and biological yield are assumed to be the main yield components (Mollasadeghi *et al*., 2011). The agronomic characteristics of the variety are indicated in details below (Tables 1 and 3). *Kombolcha* variety could be adapted under stress environments such as acidic soil and low soil fertility where other crops produce low yields and are adapted poorly adapted. Hinojosa *et al.* (2002) and Pfeiffer (1994) reported that triticale could be adapted to harsh, low-input, sustainable farming systems and it is rapidly expanding in several production systems. The new variety could be resistance to lodging and have the ability to withstand high fertility/nitrogen input.

The newly released variety, '*Kombolcha'* produced seed yield ranging between 1906.7 to 8346.7 kg ha^{-1} over the three years of production at the two locations while "*Moti*" variety produced seed yield ranging between 1730 and 8196.7 kg ha^{-1} (Table 2). The new variety, '*Kombolcha'* has a mean seed yield of 6184.78 kg ha^{-1} which was higher by about 13% and 3.1% than the seed yields obtained from *Moti* (the check variety) and the other candidate variety Acc. 2012 MS #59, respectively (Table 2). The newly released variety produced 3900 to 5100 kg ha^{-1} seed yield on farmers field as compared to Moti, which produced 2940 to 4167.6 kg ha^{-1} as well as the newly released variety and the other candidate variety (Acc. 2012 MS #59), which produced a seed yield of 3145.5 to 4320.5 kg ha^{-1} (Tables 3). The average grain yield of the '*Kombolcha'* variety on farmers' fields (4500 kg ha^{-1}) is higher compared to the world's average yield (3660 kg ha^{-1}) (FAO, 2018) as well as that of some Ethiopian varieties (2466.5 kg ha^{-1}) (Aemiro Bezabih *et al*., 2019) .

Table 1. Mean values of agronomic performances of two triticale candidate and standard check varieties in Shambu and Gedo districts of western Ethiopia, during the 2015-2017 cropping seasons.

Trait	Genotype		
	Acc.2012 MS #51 (*Bariso* variety)	Acc. 2012 MS #59	*Moti* (standard check variety)
Maturity (day)	122.2	123.2	122.8
Plant height (cm)	117.8	103.5	103.7
Panicle length (cm)	10.4	9.7	9.8
1000 grain weight (g)	49.6	47.0	44.3
Biomass(kg/ha)	35, 340.4	33, 234.7	31, 345.0
Grain yield (kg ha^{-1})	6108.9	5573.4	5406.7
Yield advantage (%)	13.0	3.1	

Table 2. Mean grain yield (kg ha^{-1}) of two triticale candidate and standard check varieties in Shambu and Gedo districts of western Ethiopia, during the 2015-2017 cropping seasons.

Year	Location	Genotype		
		Acc. 2012 MS #51 (*Bariso* variety	Acc. 2012 MS #59	*Moti* (standard check variety)
2015	Shambu	6107.0	6587.0	4813,0
	Gedo	8346.7	6250.0	6093.3
	Mean	7226.9	6418.5	5453.2
2016	Shambu	8233.3	5966.7	8196.7
	Gedo	5830.0	6490.0	5556.7
	Mean	7031.7	6228.4	6876.7
2016	Shambu	6685.0	6040.0	6049.9
	Gedo	1906.7	2106.7	1730.0
	Mean	4295.9	4073.4	896.5
	Mean of three years	6184.8	5573.4	5406.6
	SD	2347.53	1715.56	2990.94
	CV (%)	27.3	29.7	32.0

Note: SD = standard deviation and CV (%) = coefficient of variation.

Table 3. Agronomic and adaptation characteristics of "*Bariso*" Triticale variety in comparison with the standard check and other candidate varieties in Shambu and Gedo districts of western Ethiopia, during the2015-2017 cropping seasons.

Characteristics	Variety/genotype		
	Bariso variety (Acc. 2012 MS #51)	Acc. 2012 MS #59	Moti *Moti* (standard check variety)
Adaptation area			
Altitude (m a.s.l.)	2244–2784	2244–2784	1800–2700
Rainfall (mm)	> 800	> 800	>600
Seed rate (kg ha^{-1})	150	150	150
Fertilizer rate			
NPS (kg ha^{-1})	100	100	100
Urea (kg ha^{-1})	100	100	100
Days to maturity	121–123.4	121.6–125.9	120.7–124.9
1000 seed weight (g)	47.5–51.7	45–49	41.1–47.5
Plant height (cm)	113.9–121.7	102.5–105.8	101.5–105.9
Panicle length (cm)	8.8–11.	8.6–10.9	8.7–10.9
Crop pest reaction	Tolerant to pests	Tolerant to pests	Moderate
Seed yield			
Research field (kg ha^{-1})	1906.7–8346.7	2106.7–6587	1730–8196.7
Farmers field (kg ha^{-1})	3900–5100	3145.5-4320.5	2940.4–4167.6
Year of release	2019	-	2012

4. Yield Stability of the New Variety

The total variation in grain yield for the GEI was 74.56%, with PC1 and PC2 accounting for 49.48% % and 25.10%, respectively (Fig1).This shows that most of the grain yield variation was due to genotypes and environments. The result indicates that there was a great variation among the environments in terms of grain yield. Consistent with this result, Kendal and Sayar (2016) reported that there was a considerable variation among the environments in grain yield of triticale genotypes. The GGE biplot analysis revealed both candidates (2012 MS #51 and 2012 MS #59) exhibited higher stability for yield across the two locations over the three growing years. Mainly, the new variety, *'Kombolcha* (Acc. 2012 MS #51) represented by the number four was relatively close to the ideal environment in the concentric circle and near average environment axis, suggesting their potential for wider adaptability with better gain yield performances (Figure 1). The two principal components accounted for 74.56% of the total variation of which PC1 accounted for 49.48% and PC2 accounted for 25.10% of the total variation.

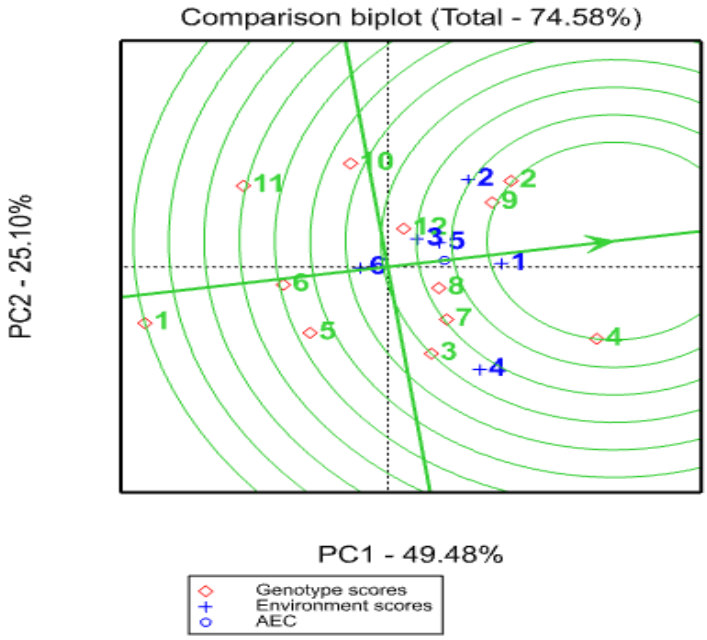

Figure 1. GGE biplot depicting the yield stability of tested genotypes in Shambu and Gedo districts of western Ethiopia, during the 2015-2017 cropping seasons [1 = 2012 MS #110, 2 = 2012 MS #100, 3 = 2012 MS #102, **4 = Kombolcha/2012 MS #51**, 5 = 2012 MS # 26, 6 = 2012 MS # 85, **7 = 2012 MS # 59**, 8 **=** 2012 MS #62, 9 = 2012 MS #88, 10 = 2012 MS # 81, 11 = 2012 MS #101 and 12 = S**tandard check variety (Moti)]** over six test environments (two locations over three years).

Table 4. The Accession and origin of the genotypes used for the study in Shambu and Gedo districts of western Ethiopia, during the 2015-2017 cropping seasons.

Number	Accessions	Source
1	2012 MS #110	Debreziet ARC/CIMMYT
2	2012 MS #100	Debreziet ARC/CIMMYT
3	2012 MS #102	Debreziet ARC/CIMMYT
4	**2012 MS #51**	**Debreziet ARC/CIMMYT**
5	2012 MS #26	Debreziet ARC/CIMMYT
6	2012 MS #85	Debreziet ARC/CIMMYT
7	**2012 MS #59**	**Debreziet ARC/CIMMYT**
8	2012 MS #62	Debreziet ARC/CIMMYT
9	2012 MS #88	Debreziet ARC/CIMMYT
10	2012 MS #81	Debreziet ARC/CIMMYT
11	2012 MS #101	Debreziet ARC/CIMMYT
12	**Moti (st.check)**	**Debreziet ARC/CIMMYT**

6. Reaction to Major Diseases

Each candidate was evaluated for its response to rusts and Septoria leaf blotch in the field. As a result, the new variety, '*Kombolcha*' was found to be resistant to moderately resistant to three rust diseases. The variety was resistant to yellow rust (0–5 R) and moderately resistant to stem rust (0–5 MR) while the standards check variety, "Moti" was found to be moderately resistant to the diseases. The other candidate variety (Acc. 2012 MS #59) was found to be moderately resistant to susceptible to the diseases (Table 5). The new variety also showed a low score for *Septoria tritici*, which is comparable with check (Moti) and the other candidate (Table 5). In general, both candidates have good resistance to major diseases. In comparison to wheat, triticale appears to have good resistance to major wheat diseases and pests including rusts (Puccinia sp.) and Septoria complex (Mohammed and Tegegn, 2019). Developing resistant triticale varieties to major diseases such steam rust (*Puccinia graminis*), yellow rust (*Puccina striiformis*) and Septoria tririci (*Mycosphaerella graminicola*) is one of the major objectives of the

breeding program. Therefore, release of the new variety 'Kombolcha' for use as a commercial variety in Ethiopia is a testament to the progress made in making the breeding program a success.

Table 5. Reaction of the new, the standard check, and the other triticale candidate varieties to stem rust, yellow rust, and Septoria tritic in in Shambu and Gedo districts of western Ethiopia, during the 2015-2017 cropping seasons.

Genotype	Diseases Reaction		
	Stem rust	Yellow rust	*Septoria tritici*
Acc. 2012 MS #51 ("*Bariso*")	0–5MR	0–5R	14.3
Acc. 2012 MS #59	5–10MR	0–15MR	12.5
Moti (standard check variety)	10MR–30S	5MR–20S	12.3

Table 6. Major infection type classes for stem, leaf, and yellow rusts in Shambu and Gedo districts of western Ethiopia, during the 2015-2017 cropping seasons.

Infection Type	Host reaction	Symptoms
I	Immune	No visible infection
R	Resistance	Necrotic/chlorotic areas with or without small sporulation
MR	Moderately resistance	Small pustules surrounded by necrotic areas
M	Moderately (resistance/resistance)	Combination of both MR and MS
MS	Moderately susceptible	Medium sized pustules, no necrosis or some necrosis
S	Susceptible	A large pustules, no necrosis or chlorosis

6. Conclusion

"Kombolcha" produced high yield, and it had a more stable performance in seed yield over locations and years than the standard check variety. The variety also showed a higher resistance to rusts and Septoria tritici. Therefore, it was released and recommended for cultivation in western Ethiopia, but could be adopted for production in similar agro ecologies in the country.

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