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SOIL & CROP SCIENCES | RESEARCH ARTICLE

Performance of triticale varieties for the marginal highlands of Wag-Lasta, Ethiopia

Aemiro Bezabih[1], Getawey Girmay[1] and Alemu Lakewu[1*]

Abstract: A field experiment was conducted during 2014 and 2015 using seven released triticale varieties in Wag-Lasta marginal high lands. Triticale (Triticosecale) is a hybrid of wheat (Triticum) and rye (Secale). The objective of the trial was to select adaptable and high yielding triticale variety for Wag-Lasta marginal high lands. Randomized complete block design with three replications and Plot size of 2.5 m length, 1.2 m width, 0.2 m row spaces were used. Phonological, agronomic and grain yield Data were taken. The combined analysis of variance showed a significant difference among the test varieties, location, and variety by location (GEI) interaction for most of the traits. Mean squares of Location was highly significantly ($P < 0.01$) different for all traits considered except spike length. Varieties were also highly significantly ($P < 0.01$) different from each other except biomass. Mean squares for variety by location interaction effects were highly significant ($p < 0.01$) for days to heading, days to maturity and significant ($p < 0.05$) for spike length and biomass; indicated the differential response of the varieties to test location for these traits. However, grain yield was not significantly affected by interaction effect that varieties were performed nearly similar in these test locations. Based on the data analysis and field evaluation variety Logawshibo followed by Dilfakare gave the highest grain yields of 30.32 qt/ha and 27.43 qt/ha, respectively. Thus, these varieties are recommended for Wag-Lasta marginal highlands and similar environment of the region. Moreover, these varieties should be demonstrated and popularized for the users.

Subjects: Agriculture & Environmental Sciences; Botany; Soil Sciences

Keywords: triticale; adaptability; grain yield; GEI; BCBD; GEI; hybrid

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PUBLIC INTEREST STATEMENT

Triticale is one of the most important to marginal areas of wag lasta as main and alternative crop, there for introduction and improving through adaptation of the crop in Wag-Lasta area is mandatory because the area is characterized by low fertile, erratic, late on set rainfall.Beside that the productivity of main cultivated crops in Wag-Lasta is very low as compared to other growing areas of Ethiopia. Therefore, substitution of like this crop to the area is crucial.

1. Introduction

Triticale (× Triticosecale, Wittmack), the first successful human-made hybrid cereal grain, was deliberately produced by crossing wheat (Triticum) as female and rye (Secale) as a pollen source. The crossing of two crops is to obtain the best characteristics of the two crops. Wheat yields and grain quality are better than rye. But rye has greater disease resistance and better tolerance to environmental stress. Triticale combines yield potential and grain quality of wheat with the disease and environmental tolerance including adaptability to difficult soils, drought tolerance, cold hardiness, disease resistance and low-input requirements of rye (Food and Agriculture Organization (FAO), 2004). Triticale has similarity with its parents but, vary in plant height, large inflorescence, seed size, and shape.

Triticale can be grown in a wide range of agro-ecologies, up to 3000 m above sea level (masl). It requires an average of 500–600 mm rainfall, well distributed during the growing season. However, it can also perform well with as little as 350 mm of seasonal rainfall (Gobeze, Mazengia, & Hidoto, 2007).

It is adapted to a wide range of soils conditions including low fertility sands, shallow soils, acidic and sodic, very high and low Ph. Triticale has more vigorous root system than wheat, barley or oats binding light soils and extracting more nutrients from the soil and its vigorous root system makes growing this plant attractive in low fertile soils, light soils and where a crop is being to better compete with weeds (Gobeze et al., 2007).

Drought and frost tolerance are the primary advantages that triticale has over the other cereal crops and thus it reduces weather risk. Additionally, its yield advantage over wheat, barley, and other small grains is also great and it resists lodging better than wheat and barley (Gobeze et al., 2007). Triticale has demonstrated high yield potential even under marginal growing conditions and could a very attractive alternative for raising cereal production globally (FAO, 2004). In certain types of marginal soils, triticale cultivars out-yield the best wheat cultivars. Research results in the drought-prone regions of North Africa have shown that triticale can be an excellent alternative crop to wheat and barley (FAO, 2004).

The protein content of triticale is higher than other cereals. Triticale has high and quality straw production and regrowth capacity after grazing. It has better disease resistance. Initially, triticale suffered from poor kernel development, but genetic improvements in kernel size and development and other agronomic improvements have made triticale an important crop.

Triticale was found that it increased farmer's net benefit compared to wheat and barley in Farta District of Amhara Region (Mesfin, Legesse, & Zerfu, 2012). Landuber, Ayalew, Woldeab, and Mulugeta (2015) also reported that there was high yield reduction in wheat than triticale by strip rust in Amhara region.

In the developed world, triticale is dominantly produced for animal feed, while in the developing countries it is produced mainly for human consumption. In Ethiopia, the grain is used for human food, while the straw is used for animal feed, roof thatching, and bedding. Even though its food quality is less than wheat and barley, the local community at South Gondar and other triticale growing environments utilize it in form of injera, flat bread, roasted grain and boiled grain. To improve the food quality of triticale they usually used blending with other cereal flour such as wheat, tef, and barley (Ahlawat, 2000; Muluken et al., 2014).

According to Central Statistic Agency (CSA) (2016) there was not solely an exact indication of area coverage and production of triticale report generally in Ethiopia and particularly in Amhara region, but there are improved varieties developed and released for production for different agro-ecologies of Ethiopia. Triticale is not well established and not a common crop in Wag-Lasta wheat and barley growing marginal areas, but Production is started in some marginal highland areas of Lasta (personal communication).

The productivity of main cultivated crops in Wag-Lasta is very low as compared to other growing areas of Ethiopia. For example productivity of Wheat in Waghimra was 11.05 q/ha (CSA, 2016). This is due to tremendous factors owing to low soil fertility, disease and pest occurrences, drought, lack of improved varieties and backward management systems. Since triticale crop has many uses and marginal alternative important crop, introduction and improving through adaptation of the crop in Wag-Lasta and other areas which characterized by low fertile, erratic, late on set and early of set rainfall is essential. Identifying best yielder and adaptable variety through adaptation reduces labor, cost, and enable to reach to farmers in a short period of time. Therefore, the objective of this trial was to identify adaptable and high yielding triticale varieties for marginal highlands of Wag-Lasta and similar agro-ecologies of the region.

2. Materials and methods

The experiment was conducted at Wag-Lasta (Lalibela, Dehana, and Woleh locations) during 20,014/20,015 for two consecutive meher main cropping seasons. The description of tested locations is indicated (Table 1). About seven nationally and regionally released triticale varieties (Logawshibo, Minet, Snan, Motti, Dilfakare, Dersolign, and Abdisa) which obtained from national and regional research centers were used. The varieties detail description indicates. (Table 2). The experiment was laid out in a Randomized complete block design (RCBD) with three replications throughout the testing locations. Each plot size was ($3m^2$) six rows spaced with 0.2 m apart and 2.5 m length. The distance was maintained 1metere and 0.5 m between replications and plots at all locations, respectively. The fertilizer rate was used 100 kg ha^{-1} and 50 kg ha^{-1} DAP ((NH4)2HPO4 and UREA or CO(NH2)2, respectively. All DAP and half of UREA were applied at sowing and remaining UREA at tillering stage. A seed rate of 150 kg ha^{-1} was used. Four middle rows were harvested and threshed for data collection leaving external two rows as a boarder. Other agronomic practices were applied equally based on the recommendations as required.

Data on grain yield was taken based on moisture measurement for cereal that was 12.5 moisture content and then after adjusting the grain by moisture meter adjusted yield was weighted after it was taken from net plot. And agronomic traits were taken from each plot. Days of heading and maturity were taken when each plot reached 50% of the head emergence and 95% of the heads attained physiological maturity, respectively. The days were calculated beginning from the date of sowing. Plant height (cm) from the ground level to the top of the plant, spike length and number of seeds per spike were taken at full maturity from five randomly selected plants of the central four rows. The mean values were recorded as per plot. Yield data was recorded on clean, dried samples. Yield data were converted to quintal per hectare. A Thousand kernels were counted and weighted. Plant disease data were not recorded since significant observable diseases were not observed.

Table 1. Description of the test locations

Locations	Years	Altitude (m.a.s.l)[¥]	Annual Rain fall	Soil type
Lalibela	2014, 2015	2145	940	EutricCambisol
Dehana	2014	2541	851.7	Eutric nitosol
Woleh	2014	2068	670	Cambisol

[¥] m.a.s.l., meters above sea level

Table 2. Description of triticale varieties

	Variety	Year of Release	Days to Maturity	Rainfall	Altitude	Yield (q/ha)	Disease reaction	Center
1	Logawshibo	2007	135	>500	1800–2600	44.24	Res. to rust	KARC
2	Minet	2002	143	2024	2600–2610	37.0	S. to rust	AdetARC
3	Snan	2002	145	2024	2600	41.9	S. to rust	AdetARC
4	Motti	2013	127–154	>600	1800–2700	40–53	Tolerant	BARC
5	Dilfakare	2007	136	>500	1800–2600	44.24	Tolerant	KARC
6	Dersolign	2012	141	>800	>2400	31.61–58.83	Tolerant	Adet
7	Abdisa	2013	127–154	>600	1800–2700	44–62	Tolerant	BARC

Source: Ministry of Agriculture; Plant variety Release, Protection, and Seed Quality Control Directorate

The analysis of variance for collected data was performed using the SAS computer program, version 9.1. Combined data analysis was performed after testing the homogeneity of error variances using Bartlett's test for the validity to combine. (Gomez & Gomez, 1984).Mean separations were determined using Duncan's New Multiple Range Test (DMRT) at 5% of significance as cited in Gomez and Gomez (1984). Since genotype–environment interaction (GEI) of grain yield was none significant, the Additive main effects and multiplicative interaction (AMMI) model for further partitioning were invalid.

3. Soil physicochemical property

Soil analysis was conduct before the experiment was come to the ground, based on our research center laboratory result the pH range was 6.23,6.3 and 6.24 for Lalibella, Woleh and Dehana respectively as shown below (Table 3) based on the procedure of filterd suspension of 1:2.5 soil to water ration using a glass electrode attach to PH meter. And with respect to textural class all the sites had clay loam and the organic matter was with the range of 6.23–6.33 for lalibella and woleh, respectively. Total nitrogen was measured by micro-kjeldehal digestion, distillation and titration method.

4. Results and discussion

The individual analysis of variance showed the existence of significant (P ≤ 0.05) difference among tested varieties for most of the traits at all locations. There was a significant difference (P ≤ 0.05)

Table 3. Soil physicochemical property

Site	Ph	ECdec/m	OM	TN(%)	Texture			Textural class
					Sand	Silt	Clay	
Lalibella	6.23	1.3	1.06	0.07	39	27	34	Clay Loam
Woleh	6.30	1.6	1.09	0.05	35	33	36	Clay Loam
Dehana	6.24	1.5	1.07	0.06	32	31	35	Clay Loam

Table 4. Mean adjusted grain yield and other agronomic traits of triticale varieties at Woleh 2014

Variety	DH	DM	PH	SL	NS	TKW	BM	GY
Logawshibo	58.6abc	115.0bc	86.86	8.3b	51.93	41.66a	75.0	24.83
Minet	59.667bac	121.0a	92.06	11.03a	57.0	36.16b	80.0	24.16
Snan	60.667ab	115.0cb	85.06	9.4b	60.86	33.16b	60.0	22.40
Motti	56.33c	113.0c	84.6	8.76b	63.66	33.8b	80.0	24.33
Dilfakare	52.33d	112.667c	86.8	8.5b	48.66	32.5b	88.33	27.33
Dersolign	62.33a	116.0b	90.2	8.60b	48.40	35.33b	73.33	23.16
Abdisa	58.33bc	114.0cb	84.4	8.53b	59.66	35.00b	66.67	22.00
Mean	58.33	115.23	87.14	9.03	55.74	35.38	74.76	24.03
DMRT	**	**	ns	*	ns	**	ns	ns
CV	3.5	1.2	5.22	8.79	14.83	6.37	18.05	14.03

ns, *, **, = Non-Significant, significant at P ≤ 0.05 and significant at P ≤ 0.01, respectively, CV = Coefficient of variation (%), DMRT = Duncan multiple range tests.
DH = Days to Heading, DM = Days to Maturity, PH = Plant Height (cm), SL = Spike Length (cm), NSPS = No.of seeds per spike, BM = Biomass (q/ha), TKW = 1000 Kernels weight (g) GY = Grain yield (q/ha)

Table 5. Mean adjusted grain yield and other agronomic traits of triticale varieties at Dehana

Variety	DH	DM	PH	SL	NS	TKW	BM	GY
Logawshibo	63.3d	128.0e	99.8bc	8.13c	45.33	37.8a	110.0	30.5
Minet	65.3	130.0c	103.0ab	10.46a	53.26	32.83bc	113.3	26.00
Snan	63.3d	126.3f	105.0a	9.1bc	53.0	34.16ab	108.3	28.33
Motti	69.66b	129.0d	99.3cb	9.0bc	55.33	30.5bc	133.3	29.83
Dilfakare	69.0b	131.0b	95.9c	8.83bc	52.53	28.66c	115.0	30.54
Dersolign	73.0a	134.0a	106.13a	9.5ab	45.86	31.1bc	101.7	24.16
Abdisa	69.0b	130.6b	96.33c	9.66ab	57.0	30.16bc	111.7	26.17
Mean	67.5	129.85	100.79	9.24	51.8	32.19	113.33	27.93
DMRT	**	**	**	**	ns	**	ns	ns
CV	1.3	0.23	2.53	6.28	10.62	6.89	8.92	15.81

ns, *, **, = Non-Significant, significant at P ≤ 0.05 and significant at P ≤ 0.01, respectively, CV = Coefficient of variation (%), DMRT = Duncan multiple range tests.
DH = Days to Heading, DM = Days to Maturity, PH = Plant Height (cm), SL = Spike Length (cm), NSPS = No.of seeds per spike, BM = Biomass (q/ha), TKW = 1000 Kernels weight (g) GY = Grain yield(q/ha)

among the varieties for days to heading and maturity, spike length and thousand kernel weight whereas, none significant difference for plant height, number of seeds per spike, biomass and grain yield at Woleh location (Table 4) in line with (Chimdesa, 2017). Except for a number of seeds per spike, biomass and grain yield for all traits showed significant (P ≤ 0.05) difference among varieties at Dehana location (Table 5). There was significant difference (P ≤ 0.05) among the varieties for days to heading, plant height, spike length and grain yield in line this finding Chimdesa, Aseffa, and Alemu (2018) and (Dargo, 2017) but insignificant (P > 0.05) difference for days to maturity, number of seeds per spike thousand kernel weight and biomass at Lalibela location (Table 6)

Table 6. Mean grain yield and other agronomic traits of triticale varieties at Lalibela

Variety	DH	DM	PH	SL	NS	TKW	BM	GY
Logawshibo	55.5b	109.83	96.33ab	8.6c	46.0	45.91	84.16	32.97a
Minet	57.16b	114.33	98.63a	10.22a	54.66	38.41	84.36	26.08b
Snan	57.33b	115.83	97.13ab	9.8ab	53.96	40.5	89.16	28.48b
Motti	60.ab	110.16	89.76b	8.8c	52.46	37.75	74.16	23.51b
Dilfakare	58.0b	109.16	89.13b	10.09ab	55.33	36.16	84.5	25.93b
Dersolign	64.5a	117.83	91.13ab	8.83c	46.76	41.25	76.25	23.8b
Abdisa	61ab	114.66	88.7b	9.35bc	53.4	37.83	85.12	24.88b
Mean	59.07	113.11	92.97	9.40	51.80	39.69	82.32	26.51
DMRT	*	ns	*	**	ns	ns	ns	*
CV	7.14	6.80	6.99	6.78	26.24	18.60	16.58	16.80

ns, *, **, = Non Significant, significant at P ≤ 0.05 and significant at P ≤ 0.01, respectively, CV = Coefficient of variation (%), DMRT = Duncan multiple range teste, DH = Days to Heading, DM = Days to Maturity, PH = Plant Height (cm), SL = Spike Length (cm), NSPS = No.of seeds per spike, BM = Biomass (q/ha), TKW = 1000 Kernels weight (g) GY = Grain yield (q/ha)

Generally, the significant difference observed for the traits days to heading and spike length whereas nonsignificant for biomass yield among the varieties at all locations. Grain yield was significant at Lalibela in line with location but none significant difference at Woleh and Dehana locations. Among the tested varieties, Logawshibo gave 32.97 q/ha highest grain yield at Lalibela location. Hence, Logawshibo was high yielder at Lalibela location.

The combined analysis of variance across the tested locations showed significant difference among the tested varieties, locations, and variety by location interaction for most of the traits. Mean squares of Location was highly significant ($P \le 0.01$) different for all traits considered except spike length (Table 7). Varieties were also highly significant ($P \le 0.01$) different from each other except biomass (Table 7). Mean squares for variety by location interaction effects were highly significant ($P \le 0.01$) for days to heading, days to maturity and significant ($P \le 0.05$) for spike length and biomass (Table 7); indicated the differential response of the varieties to test location for these traits. In other words for these traits, a particular variety may not exhibit the same phenotypic performance under different environmental conditions or different variety may respond differently to a specific environment.

However, grain yield which is an ultimate goal and important trait was not significantly affected by the interaction effect that, varieties were performed nearly similar in these test locations for grain yield. In other words, for this grain yield trait a particular variety exhibit the same phenotypic performance under different environmental conditions or different varieties may not respond differently to a specific environment. This result contradicted with findings of Muluken et al. (2014) and Solomon, Yaie, and Girma (2007) for triticale, Bezabih, Yilma, Ademe, Birhanu, and Beshir (2014) for bread wheat: reported the existence of GEI significant difference. The tested locations environmental variations (soil fertility, rainfall, temperature) might be less/no dissimilar. Therefore, there is no need for further partitioning genotype/variety/by environment interaction for stability assessment. The result confirmed with others that triticale as the crop can adapt well to all growing environments better than other cereal crops (FAO, 2004; Solomon et al., 2007). Even though GEI was none significant to select wide and/or specific adaptable, selecting better variety/is based on better grain yield performance and other important traits are possible.

Table 7. Mean square of traits from combined ANOVA for seven varieties grown in 2014 and 2015 main cropping season

Traits	Mean squares (MS)				Mean	CV (%)
	Location (L)	Varieties (V)	L x V	Pooled error		
Days to Heading	*571.26***	82.69**	20.29**	1.11	61.00	1.72
Days to Maturity	2024.01**	66.00**	20.42**	0.96	117.83	0.83
Plant Height	1027.00**	128.01**	20.96 ns	12.28	93.47	3.74
Spike Length	0.82ns	5.12**	0.82*	0.37	9.27	6.57
No. of seeds/ spike	1532.61**	191.60**	38.81 ns	57.06	52.78	14.31
Biomass	6895.90**	153.59 ns	230.51*	114.03	88.18	12.10
1000 seeds weight(g)	597.15**	108.85**	16.49 ns	16.92	36.73	11.19
Grain yield (q/ha)	70.24**	58.60**	**17.65 ns**	16.16	26.25	15.31

ns, *, **, = Non-Significant, significant at $P \le 0.05$ and significant at $P \le 0.01$, respectively, CV = Coefficient of variation (%).

Table 8. Combined Performance of triticale varieties for adjusted grain yield and other agronomic traits across four environments (across three locations and over two years)

Variety	DH	DM	PH	SL	NSPS	BM	TSW	GY
Logawshibo	58.25d	115.66d	94.83b	8.42d	47.31b	88.3	42.83a	30.32a
Minet	59.83c	119.91b	98.08a	10.48a	54.90a	90.40	36.45cb	25.54b
Sinan	59.66c	118.25c	96.08ab	9.57b	55.45a	86.66	37.08cb	26.93ab
Motti	61.50b	115.58d	90.86c	8.87cd	55.98a	90.40	34.95cb	25.30b
Dilfakare	59.33c	115.50d	90.25c	9.37bc	52.96ab	92.90	33.37c	27.43ab
Dersolign	66.08a	121.41a	94.65b	8.94cd	46.95b	81.87	37.25b	23.73b
Abdisa	62.33b	118.50c	89.53c	9.22cb	55.95a	86.66	35.20bc	24.48b
Mean	61.00	117.83	93.47	9.27	52.78	88.18	36.73	26.25
CV (%)	1.72	0.83	3.74	6.57	14.31	12.10	11.19	15.31
Duncan at 5%	**	**	**	**	**	NS	**	**

ns, *, **, = Non-Significant, significant at P ≤ 0.05 and significant at P ≤ 0.01, respectively, CV = Coefficient of variation (%).
DH = Days to Heading, DM = Days to Maturity, PH = Plant Height (cm), SL = Spike Length (cm), NSPS = No.of seeds per spike, BM = Biomass (q/ha), TKW = 1000 Kernels weight (g) GY = Grain yield (q/ha)

Likewise, thousand kernel weight and plant height also showed none significant interaction effect; indicated the similar performance of the varieties for these traits across the test environments.

The combined mean grain yield performance of varieties across test environments ranged from 23.73 qt/ha to 30.32qt/ha (Table 8). This grain yield productivity range is low as compared to 60–80 qt/ha in different world countries (CIMMYT, 1991; FAO, 2004) and 30–60 qt/ha in other Ethiopian triticale production areas (Table 2).

Moreover, the nonsignificant GE interaction implies that the genotypes had similar responses across the environments in which they were evaluated and that all the genotypes can reliably be assessed under any one of the locations used for this study. In other words, it was unnecessary to assess these genotypes simultaneously in the multi environments used for the study, thereby offering an opportunity to manage the limited resources available for the testing program.

Among the tested triticale varieties, Logawshibo followed by Dilfakare gave the highest grain yields of 30.32 qt/ha and 27.43 qt/ha, respectively (Table 8). So, these varieties were high yielder than other verities. On the other hand, the lowest grain yield (23.73 q/ha) was obtained by Dersolign followed by Abdisa (24.48 q/ha). Regarding heading, Logawshibo (58.25 days) headed earlier compared to the other tested varieties. Varieties Logawshibo, Dersolign, and Sinan showed the highest thousand kernels weight of 42.83 gm, 37.25 gm, and 37.08 gm, respectively. Inferior thousand kernel weight (33.37 gram) was recorded by Dilfakare next Motti (34.95 gram). Even though, Snan performed well as third next to Logawshibo and Dilfakare, it was susceptible to strip rust after the occurrence of 2010 outbreak (Muluken et al., 2014). Farmers' field observation was done during physiological maturity, and then based on their criteria (earliness, panicle length and seed size) Logawshibo variety was preferred first.

5. Conclusion and recommendation

The result of this study clearly indicates that except phenological parameters both vegetative and growth parameters was significant among varieties of triticlae at the three locations. Based on the result of the experiment all tested triticale varieties were adaptable across the tested locations and triticale can be used as one of the cereal crops as an alternative to Wag-Lasta marginal high

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land area. Even though in 2015 at two locations namely Woleh and Dehana attainable yield were not obtained as result of severe moisture deficit however there was attainable yield at lalibela at both season 2014/2015 and 2014 at both location, this indicates that there is a possibility to insist variety due to the presence of five environment reliable data by considering year as environment . Accordingly, Variety Logawshibo followed by Dilfakare gave the highest grain yields of 30.32 qt/ha and 27.43 qt/ha, respectively. Therefore, from this finding, it is possible to recommend that both verities were appropriate for the three location and similar agro-ecologies.

Generally based on field evaluation and data analysis result in Logawshibo and Dilfakare triticale varieties are recommended for production for marginal areas of wag lasta. Moreover, these varieties should be demonstrated and popularized in triticale growing areas of the recommended areas.

Cover image
Source: Author.

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Competing Interests
The authors declare no competing interests.

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