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Performance of Fodder Oat (Avena sativa L.) Genotypes for Yield and Yield Attributes in the Highland of Bale

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Abstract
The study was conducted to evaluate fodder oat genotypes for yield and yield attributes for four years (2007/08-2010/11) under four locations of Bale highland. Eleven fodder oats genotypes were evaluated in Randomized Complete Block Design (RCBD) with three replications with the objective to evaluate oat genotypes for yield and yield attributes and to test their adaptation performance in the highlands of Bale. It was observed that, most of the yield and yield related parameters were significantly different among the tested genotypes. The results revealed that genotype 79AB384 performed better for most important yield parameters. This genotype produced the maximum forage dry matter (DM) yield (10.3 t/ha) and seed yield (2870 kg/ha) showing the yield advantage of 19.4 and 24.5 % over the checks respectively. The analysis of variance for DM yield showed that 48% of the total sum of square was attributed to environmental effect. The genotypic and GEI (Genotype*Environment*Interaction) effect explained 4.7 and 18.7% respectively. The stability test also indicated that genotype 79AB384, CVmn79988385 and CS2(1563CR) were found more stable in dry matter yield and well adapted to the tested environments. Hence, genotypes 79AB384, CVmn79988385 and CS2 (1563CR) proved to be better performances among eleven genotypes tested under Bale highland conditions. Furthermore, similar breeding/selection activities on fodder oats and other forage varieties should be carried out to evaluate and develop varieties/ genotypes with good yield performance and widely adapted to different agro-ecologies of our country.
Keywords: Fodder oats, *Avena sativa*, herbage yield, Bale highland

Introduction

The highlands of Bale are characterized by crop-livestock mixed farming systems. Because of the steady conversion of grazing lands into crop fields shortage of feed in quantity and quality is becoming the major challenge to improve livestock production and productivity (Solomon Bogale, 2004). Considering this pressing need for livestock, it is very important for farmers to integrate cultivated forages such as fodder oats in to the farming system. Fodder oat (*Avena sativa* L.) is one of the potential annual fodder crop commonly cultivated in the highland agro-ecologies of Ethiopia. It is well adapted to wide range of soils and relatively tolerant to moisture stress, water logging and frost. Oats can be a good source of animal feed in the dry season if harvested at the right stage of growth, cured and stored as hay. So far, some oat varieties were recommended for fodder production in the Bale highlands. Fodder cultivars have to produce large amounts of digestible green fodder of good quality and resistant to potential plant diseases that can limit fodder yield in the production areas.

Oat genotypes could vary in forage yield performance and adaptation to specific situation. Crop yield is a product of the genotype and the environment in which the crop has been grown. Environment for crop cultivation cannot be changed but genotype can be modified by hybridization and bio-tech methods to suit the local soil and climatic conditions. This indicates that the genetic variability in crops is important for development of varieties suitable for diverse agro-climatic zones. Evaluation of the performance of genotypes across diverse environmental conditions is important for selecting superior cultivars for the target environment. Hence, this study was designed to evaluate oat genotypes for yield and yield attributes and to test their adaptation performance in the highland agro-ecology of Bale.

Materials and Methods

The experiment was carried out from 2007/08 to 2010/11 at four locations *via,* Sinana Agricultural Research Center (SARC), Robe, Agarfa and Lower Dinsho of Bale highlands. Sinana Agricultural Research Center is found at an altitude of 2400 m.a.s.l. The mean annual rainfall is 563-1018 mm with minimum and maximum temperature of 7.9 and 24.3°C, respectively. The other experimental sites were Robe, Agarfa and Lower Dinsho with an altitude of 2400 – 2600 m.a.s.l, respectively. The farming systems of the area are classified as a mixed cereal-livestock production system. The soil types of the study area are mainly clay in texture (dark brown Vertisols) with slightly acidic reaction (SARC, 2008). There are two distinct seasons '*Ganna*' (extending from March to July) and '*Bona*' (extending from July to December) which are allows double cropping. Bimodal rainfall condition is a common phenomenon, especially in the study sites. A total of eleven oats genotypes including one adapted check were evaluated in the present study. The experiment was laid down in randomized complete block design (RCBD) with three replicats using a plot size 2.4 x 1.5 m with eight rows. Seed rate of 80 kg/ha was applied. Seeds were planted in rows spaced 30 cm apart. DAP fertilizer was applied at the rate of 100 kg/ha at the time of sowing. Weeds were kept at minimum by hand weeding. Data was recorded on stand percentage, plant height (cm), days to dough stage, leaf to stem ratio, dry matter yield (t/ha), days to seed maturity and seed yield (kg/ha).

Statistical analysis

Means, mean square of errors (MSE) and percent coefficients of variation (CV%) for all agronomic traits were analyzed using the Proc GLM (SAS 1998). Genotype treatment means were compared using Least Significant Difference (LSD) test at 5% level of probability (Steel and Torrie, 1980). Stability analysis was performed using regression analysis to determine genotypic stability. Correlation coefficients among the agronomic and yield traits were also calculated by International Rice Research Institute (IRRI) stat computer program (IRRI Stat, 2003).

Results and Discussions

Mean values of yield and yield attributes

The mean value of agronomic and yield parameters of 11 fodder oats genotypes tested across 16 environments are showed in the Table 1 below. The analysis result showed that there were significant differences ($P<0.05$) among oat genotypes with respect to agronomic and yield parameters. There was a significant difference in fodder yields of tested genotypes. Maximum DM yield (10.3 t/ha) was obtained by genotype 79AB384 and following genotype CVmn which gave 9.3 t/ha DM yield. Whereas, the minimum (7.7 t/ha) DM yield was produced by the genotype 12754. Genotype 79AB384 produced 24.1% more DM yield as compared to the check. Highest seed yield were obtained from genotype 75(2SRCPX) (2980 kg/ha) followed by genotype 79AB384 (2870 kg/ha). The lowest seed yield (21.7Qt/ha) was found from the check (Jassari). The respective increase in seed yield obtained by genotype 75(2SRCPX) and 79AB384 are 27.1 and 24.3 % over the check indicating that these genotypes were better performance as compared to the rest entries. On the other hand, genotype CVmn and check (Jassari) have taken maximum days of 107.8 and 108.1 respectively to reach dough stage of growth. The data also indicated that there were significant differences ($P<0.05$) in plant height among the genotypes. Genotypes C7512SRCPR (131.1cm), 79AB384 (129.4 cm), CVmn79988385 (132.2 cm) and CVmn (130.9 cm) were among the tallest genotypes. These genotypes may be used for further breeding activities to develop tall planting materials. Similarly, there were significant differences for leaf to stem ratio. The maximum leaf to stem ratios were recorded for genotypes 79AB384 (0.91), 12754(0.90) and 80 AB 2691(0.90). However, the observed values between these genotypes were not statistically significant ($P>0.05$). The differences ($P<0.05$) that observed for most agronomic and yield parameters, however, do verify the varietal and adaptability differences amongst the tested genotypes.

Table 1. Mean values of yield and agronomic parameters of fodder oat genotypes tested in the highlands of Bale, Ethiopia, 2011-12/13

Genotypes	DDS	DSM	PH (cm)	SP	LSR	SY (kg/ha)	DMY (t/ha)
C7512SRCPR	103.8^{h}	147.1^{ef}	131.1^{a}	79.4^{bcd}	0.50^{e}	2680^{bcd}	9.1^{bc}
75(2SRCPX)	106.5^{cde}	148.5^{cd}	122.5^{c}	80.5^{ab}	0.77^{bcd}	2980^{a}	8.4^{de}
79AB384	105.9^{def}	148.5^{cd}	129.4^{ab}	82.1^{a}	0.91^{a}	2870^{ab}	10.3^{a}
C712/SRX 80AB 2207	105.7^{ef}	149.2^{bc}	123.6^{c}	77.4^{de}	0.79^{abc}	2710^{bcd}	8.7^{bcde}
80AB	106.4^{cd}	149.4^{ab}	125.2^{bc}	78.8^{bcd}	0.65^{d}	2710^{bcd}	9.0^{bcd}
12754	104.2^{g}	146.4^{f}	102.8^{e}	77.6^{cde}	0.90^{a}	2500de	7.7^{f}
CV mn 79988385	107.1^{b}	148.7^{cd}	132.2^{a}	80.8^{ab}	0.84^{ab}	2860^{ab}	9.2^{bc}
80AB2691	106.8^{c}	150.5^{ab}	114.3^{d}	76.1^{e}	0.90^{a}	2430^{e}	8.1^{ef}
CS2(1563 CR)	104.9^{fg}	148.8^{c}	117.2^{d}	79.8^{abc}	0.71^{cd}	2660^{cd}	9.0^{bcd}
CVmn	107.8^{ab}	149.8^{b}	130.9^{a}	81.8^{a}	0.74^{bcd}	2710^{bcd}	9.3^{b}
Check (Jassari)	108.1^{a}	150.3^{a}	123.2^{c}	73.5^{f}	0.80^{abc}	2170^{f}	8.3^{def}
Mean	**106.1**	**148.8**	**123.8**	**78.9**	**0.77**	**2660**	**8.85**
LSD (5%)	**1.01**	**1.15**	**3.31**	**2.26**	**0.12**	**2.31**	**0.76**
CV (%)	**2.3**	**1.9**	**6.6**	**7.1**	**30.1**	**21.5**	**21.4**

[1]DDS = Days to dough stage, DSM = Days to seed maturity, PH= plant height; SP= Standing percentage; LSR= Leaf to stem ratio; SY = Seed yield; DMY= Dry matter yield; LSD=Least significant difference. CV=Coefficient of variation; Figure having the same Letters with in column are not significantly ($P>0.05$) differ [2]Values followed by different letter (s) are significantly ($p<0.05$) differ

Analysis of Variance (ANOVA)

The analysis of variance indicated that the mean squares for environments, genotypes, and G × E were highly significant *(P* = 0.05) for DM yield (Table 2). It shows about 48% of the total sum of square for DM yield was attributed to environmental effect. The genotypic and GEI effect explained 4.7 and 18.7% respectively. The large environmental sum of squares indicated that environments were diverse and causing most of the variation in herbage DM yield. The higher magnitude of the GEI sum of squares indicated that there were differences in genotypic response across environments. Chaudhary *et al*. (1985) have also evaluated the suitability of oats as a forage crop under different agro-climatic conditions. This variability was mainly due to the distribution of rainfall, which differed greatly across locations and seasons during the experimental years.

Table 2. Pooled analysis of variance for DM yield of fodder oats genotypes tested in the highland of Bale

Source of variation	Df	Sums of squares	Mean squares	F value/ratio	Explained (%)
Year	3	728.6	242.86	66.9**	16.5
Location	3	545.6	181.88	50.1**	12.3
Replication	2	4.4	2.19	0.6 NS	0.1
Location x Replication	6	14.1	2.36	0.65 NS	0.3
Genotype	10	206.7	20.67	5.7**	4.7
Location x year	9	848.8	94.31	26.0**	19.2
Genotype x year	30	91.2	3.04	0.8 NS	2.1
Location x genotype	30	303.3	10.11	2.8**	6.8
Location x genotype x year	90	435.6	4.84	1.3*	9.8
Residual	344	1249.6	3.63		
Total	527	4427.8			

Performance of tested genotypes across locations

The average dry matter yield (t/ha) and their rank for 11 fodder oat genotypes tested across four locations over four consecutive years are presented in table 3. The highest dry matter yield 11.81 t/ha were obtained from genotype 80AB at Sinana on-station next to C712/SRX 80AB 2207 (11.08 t/ha), 79AB384 (11.25 t/ha) and CVmn79988385 (11.04 t/ha), while the lowest 5.23 t/ha were recorded by genotype 80AB2692 at Lower Dinsho which reveals the mean values for dry matter yield across locations over four years brought a significant change among genotypes reflecting the presence of variability due to genotypic performance, environmental impact and the interaction. On the other hand, most of genotypes tested at Sinana on-station perform better than the other sites in contrary with the lower Dinsho which results poor DM yield.

Table 3. Mean values of genotypes across tested sites for Dry Matter Yield (t/ha) (2011-2013)

Genotypes	Sinana on-station	Robe	Lower Dinsho	Agarfa	Over all mean	Rank
C7512SRCPR	9.93	8.76	8.27	9.67	9.16	4
75(2SRCPX)	10.37	7.42	7.79	8.35	8.48	8
79AB384	11.25	10.47	8.89	9.85	10.12	1
C712/SRX 80AB 2207	11.08	9.27	6.02	8.55	8.73	7
80AB	11.81	9.62	6.22	8.47	9.03	6
12754	8.70	7.94	6.84	7.31	7.70	11
CVmn79988385	11.04	8.69	8.55	8.61	9.22	3
80AB2691	10.40	8.90	5.23	8.00	8.13	10
CS2(1563 CR)	10.07	9.40	7.48	9.24	9.05	5
CVmn	10.39	9.16	9.13	8.78	9.37	2
Check (Jassari)	7.87	10.38	7.25	8.36	8.47	9
Grand mean	**10.27**	**9.09**	**7.43**	**8.65**	**8.86**	

Stability performance of genotypes

As indicated in the Table 4, most of the tested genotypes have a regression coefficient approximating to 1 and had small deviation from regression (S^2di), and thus possessed average stability. According to the Finlay and Wilkinson (1993), regression coefficient approximating to 1.0 indicates average stability, but must always be associated and interpreted with the genotype mean yield to determine adaptability. When the regression coefficients are approximate to 1.0 and associated with high yield mean, genotypes are adapted to all environments. Regression coefficient above 1.0 indicates genotypes with increase sensitivity to environmental change, showing below average stability and great specific adaptability to high yielding environments. Regression coefficients decreasing below 1.0 provide a measure of greater resistance to environmental change, having above average stability but showing more specific adapted to low yielding environments. Genotypes 79AB384 and CVmn79988385 are most stable and desired genotype as compared to the other genotypes since the regression coefficients approximating to unity and had one of the lowest deviations from regression and also have above average mean yield. Eberhart and Russell (1966) also stated that genotypes with high mean yield, regression coefficient equal to unity (bi=1) and deviation from regression as small as possible ($S^2di=0$) are considered stable and a desirable genotypes. In contrast, genotypes 80AB and C712/SRX80AB2207 with regression coefficients relatively greater than one were below average stability and hence they are sensitive for environmental change and specifically adapted to high yielding environments. Genotypes CS2(1563 CR), C7512SRCPR, 12754 CVmn and Check (Jassari) having above average stability are most specifically adapted to low yielding environments. This indicates that the genotypes were differed in their pattern of response relative to each other in the various environments. It can be generalized that, the use of appropriate stability parameter is necessary for identifying the most adapted, responsive and stable genotypes. A desirable genotype/cultivar should be the one whose yield is consistent over several locations and performs best in the recommended environmental condition.

Table 4. Stability analysis of the tested genotypes for DM yield (t/ha) in the highland of Bale

Genotypes	Mean yield (t/ha)	b_i	S^2di	Rank
C7512SRCPR	9.1	0.128	0.12	6
75(2SRCPX)	8.4	0.571	1.22	9
79AB384	10.3	0.831	0.06	1
C712/SRX 80AB 2207	8.7	1.48	0.84	8
80AB	9.0	1.34	0.82	4
12754	7.7	0.527	0.23	11
CVmn79988385	9.2	0.893	0.73	2
80AB2691	8.1	1.03	1.12	7
CS2(1563 CR)	9.0	0.32	0.06	3
CVmn	9.3	0.487	0.9	5
Check (Jassari)	8.3	0.165	2.86	10
Mean	**8.83**	**0.65**	**0.82**	

Correlation coefficient among yield and yield related traits

Spearman's coefficient of rank correlation was computed among all the agronomic and yield parameters (Table 5). Some of the parameters showed significant and positive correlations between characters. Dry matter yield has significant ($P<0.05$) and positive correlation coefficient with all agronomic parameters except days to seed maturity and seed yield. Similarly, correlation coefficient among plant height and DM yield (r=0.611) was found to be highly significant and positively correlated. Furthermore, the study conducted by Dhumale and Mishra (1979) also shown that fresh fodder yields were positively correlated with plant height. The standing percentage and leaf to stem ratio were negatively correlated with days to dough stage. The seed yield increased with increasing days to dough stage and seed maturity whereas it is negatively correlated with plant height. There were non- significant rank correlation between SY and SP (r=-0.077), and LSR (r=0.038). On the other hand, non--significant correlation were observed between standing percentage and seed yield. This implies that there is no strong relationship in detecting the good yielder genotype.

Table 5. Spearman rank correlation coefficient among agronomic parameters of 11 genotypes tested across location in the highlands of Bale, Ethiopia, 2011-12/13

Entry name	DDS	DSM	Ph	Sp	Lsr	Sy (kg/ha)
DSM	0.119*					
Ph	0.289*	0.281*				
Sp	-0.095	-0.182*	o.310*			
LSR	-0.046	0.281*	-0.147*	-0.091*		
Sy(kg/ha)	0.325*	0.085*	-0.307*	-0.077	0.038	
DM yield (t/ha)	0.194*	0.076	0.611**	0.410*	0.197*	-0.100

Conclusion

A study conducted to evaluate the performance of different oat genotypes showed that the genotypes tested have distinctive yield and agronomic attributes. Genotype 79AB384 performed best in most important agronomic and yield parameters. This genotype produced the maximum forage DM yield (10.3 t/ha) and seed yield (2870 kg/ha) showing the yield advantage of 19.4 and 24.5 % over the check respectively. Moreover, stability test also indicated that genotype 79AB384, CV mn79988385 and CS2 (1563 CR) were found the most stable with respect to DM yield superiority and environmental adaptation. Hence, these genotypes proved to be the best among the tested genotypes for the highland of Bale. Moreover, similar breeding/selection activities on fodder oats and other forage varieties should be carried out to evaluate and develop varieties/ genotypes with good yield performance and widely adapted to different agro-ecologies of our country.

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