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Evaluation of Oats (*Avena sativa*) Genotypes for Seed Yield and Yield Components in the Highlands of Gamo, Southern Ethiopia

Atumo Tessema and Kalsa Getinet
Arba Minch Agricultural Research Center, P.O.Box 2228, Arba Minch, Ethiopia
Corresponding: tessema4@gmail.com , +251-912-174-497

አህፅሮት

የሲናር መኖ ዘር ምርታማነትን ለማሻሻል በ14 ዝርያዎች በኤዞ ኦቴ ሙከራ ጣቢያ ከ2008 እስከ 2009 ዓ.ም. የምርት ዘመን ለሁለት ተከታታይ ዓመታት የዘር ምርታማነት ግምገማ ተካሂዷል፡፡ ሙከራው የመሬትን ለምነት ባገናዘበ መልኩ ሶስት ጊዜ (three replications) ተደጋግሞ የተዘራ ሲሆን የተለያዩ የባህሪ መረጃዎችን በመሰብሰብ የዘር ምርታማነት ተገምግሟል፡፡ በዝርያዎች መካከል የታየው ልዩነት በመኖ ምርታማነት ILRI-15153A ሌላውን ዝርያ CI-8233 አስከትሎ ተክሎቹ ያላቸውን የቅጠል ብዛት፣ የቅጥያ ብዛት፣ የተክሉ ቁመት እና አጠቃላይ ምርት የተሻለ መሆኑ ተረጋግጧል፡፡ የተለያዩ ዝርያዎች የተለያየ የዘር ምርት መጠን የታየባቸው ሲሆን CI-8233 ዝርያ ILRI-5527A፣ CI-8251 እና ILRI-5526 አስከትሎ ከሌሎች አንፃር ከፍተኛ የዘር ምርት በኪሎ ግራም፣ የዘር ግንድ መጠን፣ የሺህ ዘር ክብደት እና ሃርቨስት ኢንዴክስ አስመዝግቧል፡፡ የሲናር ባህሪ መለኪያዎቹ እርስ በእርስ ያላቸው ቁርኝት ሲታይ የቅጥያዎች መጠን፣ የዘር ግንድ፣ ሺህ ዘር ክብደት እና ሃርቨስት ኢንዴክስ መጨመር በዘር ምርት ላይ ቀጥተኛ ጥቅም እንዳለው ታይቷል፡፡ አጠቃላይ የመኖ ምርታማነት ደግሞ ለማበብ ከሚፈጀው ጊዜ፣ ከተክሉ ቁመት እና የዘር ግንድ ርዝመት ጋር ቀጥተኛና ጠቃሚ ግንኙነት እንዳለው ታይቷል፡፡ በዚህ መሠረት የሲናር መኖ ለማምረት የሚፈልጉ አካላት ሙከራው በተደረገበት አካባቢና በተመሳሳይ ሥነ ምህዳር CI-8233, ILRI-15153A, ILRI-5527፣ CI-8251 እና ILRI-5526 ዝርያዎችን ለሲናር ዘር እና መኖ ምርታማነት ማሻሻያ እንደ አማራጭ ቴክኖሎጂ መጠቀም እንደሚችሉ ተረጋግጧል፡፡

Abstract

The field experiment was laid out in a randomized complete block design with three replications to evaluate the seed yield performance of fourteen oat varieties at Ezo Ote during the main cropping seasons of 2016 and 2017. Varieties in the trial were ILRI-5431A, ILRI-5444A, ILRI-5490A, ILRI-5499A, ILRI-5526A, ILRI-5527A, ILRI-15152A, ILRI-15153A, ILRI-16101A, CI-8233, CI-2291, CI-8251, CI-2252 and CI-80AB2806. Data was recorded for days to flowering (DTF 50%), plant height, leaf number per plant, tiller number per plant, panicle length, seed per spike, 1000 seed weight, biomass yield, seed yield and harvest index. The varieties showed significant variations in yield and yield related parameters that ILRI-15153A followed by CI-8251 and CI-8233 varieties of oats had a higher number of leaves per plant, number of tillers per plant, plant height and biomass yield. CI-8233 followed by ILRI-5527A, CI-8251 and ILRI-5526A varieties had higher seed yield, optimum spike number, thousand seed weight and harvest index. Oats seed yield positively correlated with tiller number per plant, spike number, thousand seed weight and harvest index whereas biomass yield positively correlated with the days to flowering, plant height, panicle length and seeds per spike. Hence, ILRI-15153A, CI-8233 and CI-8251 for biomass yield whereas CI-8233, ILRI-5527A, CI-8251 and ILRI-5526A genotypes could be recommended for seed yield, in Ezo Ote and similar agro-ecology.

Keywords: *Avena sativa*, correlation, oats, yield

Introduction

Oats (*Avena sativa* L.) is well-adapted and productive fodder and food crop grown in the highlands of Ethiopia under rain fed conditions with minimum input usage (Gebremedhin *et al*., 2015). Compared to other cereals, oat is reputed to be better suited for feed production under marginal environments, including cool wet climates and soils with low fertility (Hoffmann, 1995). Oat grain makes a good balanced concentrate in the ration for poultry, cattle, sheep and other animals (Arora, 2014). Forage experts (Mengistu *et al.*, 2016) attest that forage seed production has not been given due attention in the national forage research and development endeavors.

Likewise, forage seed and vegetative planting material availability in Southern Ethiopia in particular together with poor resource capacity of the farmers in the subsistence production system has hindered forage development. Limited research has been conducted on forage seeds production and so there is no available technology on forage seed crop management in the region. Oats varieties selection depending on the potential seed and fodder yield, disease and insect management and maturity of the crop is important decision to promote forage development in Southern Ethiopia. Therefore, the objective of this study was to evaluate and identify the performance of oat varieties with optimum seed yield for forage development in the Southern highlands of Ethiopia.

Materials and Methods

Description of the study area

Field experiment on varietal evaluation of oats (*Avena sativa*) seed production potential was conducted in 2016 and 2017 main cropping season (July to November) at Arba Minch Agricultural Research Center, Ezo Ote substation (N $6^0$18’32’’ E $37^0$33’59’’ with an altitude of 2985 meter above sea level). The weather data like average annual (in monthly based) rain fall, maximum and minimum temperature and relative humidity presented in figures 1, 2 and 3, respectively. Climatic conditions proved to have a great influence in grain yield of oats (Tamm 2003). Regarding the soil chemical and physical properties of experimental location pH 4.8, organic carbon (%) 2.4, nitrogen (%) 0.308, available phosphorus (ppm) 3.2 and exchangable potassium (ppm) 11.2 with clay loam texture(Wassie and Shiferaw 2011). The location where the experiment conducted was observed to be too acidic soil and characterized by very low availbale phosphorus and exchangable potassium (Jones 2001).

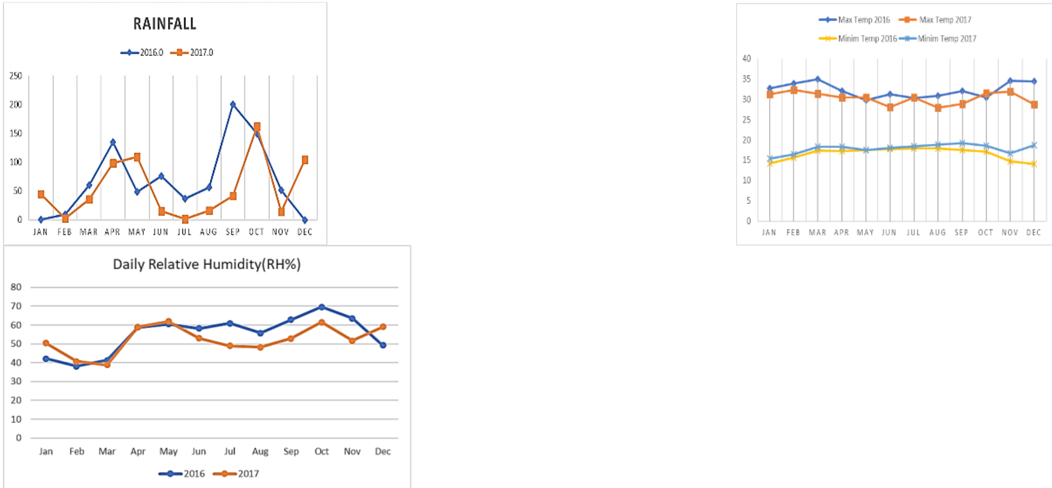

Figure1. Monthly average rainfall, maximum and minimum Temperature (°c) and Relative humidity in 2016 and 2017 at Arba Minch

Treatments and experimental design

The experiment consisting of 14 oats varieties treatment with three replication was laid out in randomized complete block design (RCBD). The seed of 14 oats varieties (ILRI-5431A, ILRI-5444A, ILRI-5490A, ILRI-5499A, ILRI-5526A, ILRI-5527A, ILRI-15152A, ILRI-15153A, ILRI-16101A, CI-8233, CI-2291, CI-8251, CI-2252 and CI-80AB2806) sown in plot (3x2 m) lines of 20 cm apart using drilling method in main cropping seasons of 2016 and 2017. All recommended field management practices and packages such as land preparation, weeding and fertilizer applications (100 kg/ha NPS as basal and 100 kg/ha urea in split application) were applied in a similar manner for all the plots in each of the treatments.

Data collection

Data was collected from four central rows for all parameters including days to soft dough stage (DTF 50%), plant height, tiller number per plant, leaf number per plant, panicle length, seed per spike, 1000 seed weight, biomass yield, seed yield and harvest index.

Statstical analysis

The data recorded was statstically analazed using the analysis of variance method and significant means separated by using least significance difference (LSD) at 5% propability level by Genstat stastical sofware and Correlation analysis using SAS software package (VSN International Ltd, 2013; SAS, 2002).

Results and Discussions

Days to 50% flowering, plant height, tiller number per plant, leaf number per plant, seed per head, 1000 seed weight, biomass yield, grain yield and harvest index shown significant variation among oat genotypes.

The genotypes mean value to days to flowering was presented in table 1. Genotypes CI-80AB2806 and ILRI-16101A took maximum days (147) to attain 50% flowering which was statistically at par with CI-8251and CI-2252 which flowered in 144 and 131 days, respectively. ILRI-5527A got minimum days (92) to 50% flowering. The variation among oat genotypes in days taken to flower may be due to their varietal physiognomies and adaptability which was previously reported by Nawaz *et al* (2004).

There was significant variation recorded for plant height among oat genotypes in 2016 and 2017 cropping seasons(Table 1). ILRI-15153A produced the maximum height (147 cm) but it did not statistically different with ILRI-5526A(120.1 cm), ILRI-5444A(117.5 cm), ILRI-15152A(119.6 cm) and CI-8251(118.7 cm) in 2017 and ILRI-15153A recorded highest plant hight in 2016 also, while the shortest plant height (69.6 cm in 2016 and 79.3 cm in 2017) recorded forILRI-5499A in both cropping seasons (Table 1). The differences among varieties in plant height were due to differences in genetic makeup and it is a foremost feature contributing towards forage biomass yield (Gebremedhin *et al* 2015).

Number of tillers per plant showed significant ($P<0.05$) variation among oat genotypes in 2016 and 2017 cropping seasons (Table 1). Maximum number of tillers recorded for ILRI-5490A (9.2) in 2017 and ILRI-15153A in 2016 that produced 11.3. ILRI-15153A has shown the optimum number of tillers among oat varieties in both seasons.The lowest (4.6) number of tiller per plant was recorded for variety CI-80AB2806. Variation in tiller number per plant among oat genotypes was previously reported by Gebremedhin *et al.*, (2015). It was previously reported that reduced tillering facilitates flowering and maturity, uniform panicle size and heavier grains (Mohanan and Mini, 2008).

Plant leaf number in this experiment was significantly ($P<0.001$) varied among oats and was ranging from 3.3 to 6.9. The maximum number of leaves per plant was recorded for variety ILRI-16101A (6.9) and ILRI-15153A (6.7) at par where as minimum number of leaves per plant was recorded for CI-2291 (3.3). Plant leaves play agreat role in growth and development of plants thereby influence forage biomass yield.This result agrees with Gebremedhn *et al.*, (2015).

Table 1: Mean values of oat genotypes for days (50%) to flowering(DTF), plant height (PH cm), tiller number (TNPP) and Leaf number per plant (LNPP) at Ezo Ote, 2016 & 2017

Oat Genotypes	DTF (50%)	PH (cm)		TNPP		LNPP
		2016	2017	2016	2017	
ILRI-5431A	121bc	108.8a	111.1bc	3.6e	6.2cde	4.9b
ILRI-5444A	98.3a	97.5abc	117.5abc	5.5bcd	5.4cde	4.5bc
ILRI-5490A	98.3a	85.1bcde	99.5bcd	5.1cd	9.2a	3.5de
ILRI-5499A	111ab	69.6e	79.3d	4.9cd	5.8cde	4.3bcd
ILRI-5526A	98.3a	75.8cde	120.1ab	6.5b	6.667cd	4.2bcd
ILRI-5527A	92a	76.1cde	116.1bc	5.5bcd	6.533cde	4.7bc
ILRI-15152A	98.3a	93.8abcd	119.6abc	6bc	7.133bc	4.1bcde
ILRI-15153A	111ab	107ab	147.3a	11.3a	8.933ab	6.7a
ILRI-16101A	147d	71.9de	109.5bc	4.6de	5de	6.9a
CI-8233	121bc	95.8abc	111bc	4.8d	6.067cde	4.4bc
SRCPX80AB2291	121bc	76.8cde	102.3bcd	4.9d	5.067de	3.3e
CI-8251	144d	83.7cde	118.7abc	5.5bcd	5.333cde	3.8cde
CI-2252	131cd	65.3e	89.6cd	4.8d	5.067de	4cde
SRCPX80AB2806	147d	107.9ab	113.6bc	4.6de	4.6e	4.5bc
CV%	9.9	15.8	16.1	11.6	19.3	11.9
Variety(13)	***	***		***		***
Year(1)		***		**		
VarietyxYear(13)		NS		***		

Panicle length variation from 18 cm (ILRI-5499A) to 27.33 cm (CI-8233) among oat genotypes was not statstically significant in the present experiment (Table 2). More panicle length observed in some oats may be due to early initiation, longer growing duration with early flowering.

Significant (P<01) variation among genotypes observed for spikelet number was ranging from 14.67 (ILRI-5499A) to 21.8 (SRCPX80AB2291) in this experiment(Table 2). Seed per head also significantly (P<0.001) varied among oats. Maximum number of seed per spike recorded for ILRI-16101A (80.67) whereas the minimum seed number recorded for ILRI-5431A(26.53). The significant variation among wheat varieties for seed per spike was previously reported by Bergene and Balcha (2016). The potential of wheat spike is determined by the number of seeds per spike which is an important yield component of seed yield (Shah *et al.*, 2011).

1000 seed weight in this experiment was significantly varied among oats was ranging from 19.6 to 49.67 grams (Table 2). The maximum seed weight recorded for ILRI-5490A (49.67 g) followed by ILRI-15152A (40 g) and ILRI-5444A (39.67 g), whereas the minimum was for ILRI-16101A (19.67 g). Significant impact on 1000 seed weight was reported for wheat cultivars by Zareian *et al.*, (2012) and barley by Rukavina et al (2002). Differences among oat genotypes for those traits in similar environment could be due to their genetic variation.

Table 2: Mean values of oat genotypes for panicle length (PL), spikelet number (SN), seed per spike (SPS) and 1000 seed weight (TSW), Ezo Ote, 2017

Oat Genotypes	PL (cm)	SN	SPS	TSW
ILRI-15152A	24.33	18.73	47.4[bc]	40[b]
ILRI-15153A	23.13	17.53	55.67[b]	26.67[ef]
ILRI-16101A	23.53	21.47	80.67[a]	19.67[f]
CI-2252	22.33	16.27	34.07[cd]	35.67[bcde]
SRCPX80AB2291	24.93	21.8	55.67[b]	39.33[bc]
ILRI-5431A	22.93	16.67	26.53[d]	38.67[bcd]
ILRI-5444A	27.2	16.33	40.27[bcd]	39.67[b]
ILRI-5490A	23.93	17.8	49.2[bc]	49.67[a]
ILRI-5499A	18	14.67	34.67[cd]	38.67[bcd]
ILRI-5526A	21.8	17.07	44.67[bc]	31.67[bcde]
ILRI-5527A	24.67	21.13	54.2[b]	39.33[bc]
SRCPX80AB2806	24.07	17.73	41.33[bcd]	30[de]
CI-8233	27.33	19.47	51.67[b]	37[bcd]
CI-8251	21	17.87	40.93[bcd]	30.33[cde]
CV%	21.8	16.3	19.9	15.4
Vareity(13)	NS	**	***	***
Year(1)				
VareityxYear(13)				

Above ground biomass yield performance significantly varied among 14 genotypes of oats in the study area (Table 3). Maximum biomass yield was achieved in 2016 for genotypes ILRI-15153A followed by ILRI-16101A and in 2017 ILRI-15153A (17504 kg ha^{-1}) followed by CI-8233 (13336 kg ha^{-1}) which was statistically at par with ILRI-5526A (13058 kg ha^{-1}), CI-8251 (12891 kg ha^{-1}) and ILRI-5527A (12503 kg ha^{-1}). Whereas, minimum biomass yield was obtained from genotypes ILRI-5490A, ILRI-5499A, ILRI-15152 in both years, from genotypes ILRI-5444A in 2016 and CI-2252 in 2017 cropping season. Biomass difference among oat varieties was previously reported by Amanullah and Stewart (2013).

Significant ($P<0.001$) differences among 14 oat genotypes recorded for the seed yield (Table 3). The maximum seed yield in 2016 was recorded for genotype CI-80AB2806 (2450 kg) followed by CI-8233, ILRI-15152A and ILRI-5431A. The seed yield observed in 2017 was optimum for the genotypes ILRI-5526A and ILRI-5527A followed by CI-8233 and CI-8251. The mean value of genotypes over the year showed the higher and consistent seed yield for CI-8233 followed by ILRI-5527A. These genotypes CI-8233, ILRI-5527A, CI-8251, ILRI-5526A, ILRI-5490A and ILRI-5444A provided higher seed yield at rate of 31.6%, 27.7%, 23.9%, 20.5%, 14.9% and 11.6%, respectively when compared to the average yield of genotypes in the trial. On the otherhand, oat variety CI-2252 produced minimum seed yield in both years of observation (Table 3). Seed yield variation among oats genotypes grown in similar environment was due to genetic potential of the genotypes and their adaptability. Amanuel *et al.,* (2019) also reported higher seed yield for oat variety CI-80AB2806.

There was significant ($P<0.05$) harvest index variation recorded among oat genotypes in 2016 and 2017 main cropping season (Table 3). In 2016 ILRI-15152A showed higher harvest index and ILRI-5444A, ILRI-5490A, CI-8233, SRCPX80AB2806 and ILRI-

5499A at par. In 2017 ILRI-5490A showed consistency in result of harvest index and significantly higher than other varieties in test (Table 3). This rsult agrees with Jalani *et al.*, (2004) that about 98% of the seed yield variation in each population was due to variation in growth rate and harvest index. Increasing the harvest index is a major route to higher yields and the low harvest indices indicate less effective utilization of resources on cultivars (Peltonen-Sainio 2008).

Table 3: Mean values of oat genotypes for biomass yield (BMY), seed yield(SY) and harvest index(HI) at Ezo Ote, 2016 & 2017

Oats Varieties	BMY kg ha^{-1}			SY kg ha^{-1}			HI		
	201	201	Mea	201	201	Mea	20	201	Mean
ILRI-5431A	5446	777	6612.	2050	114	1597.	0.3	0.15	0.15
ILRI-5444A	361	105	7085	1831	166	1748	0.5	0.1	0.16
ILRI-5490A	4001	727	5640	1900^{b}	170	1800	0.4	0.23	0.23
ILRI-5499A	4056	689	5473	1650	70	1178.	0.4	0.1	0.10
ILRI-5526A	4418	130	8738	1542	223	1886.	0.3	0.1	0.17
ILRI-5527A	4779	125	8641	1839	216	2000	0.3	0.1	0.17
ILRI-15152A	3890	500	3890	2056	69	1374	0.5	0.14	0.14
ILRI-15153A	878	175	1314	1711	131	1510.	0.2	0.0	0.07
ILRI-16101A	6501	861	7557	130	112	1214.	0.2	0.13	0.13
CI-8233	5001^{b}	133	9168.	213	198	2060	0.47	0.1	0.15
SRCPX80AB2291	4501	833	6418	1667	905	1286	0.3	0.11	0.11
CI-8251	5946	128	9418.	1950	193	1941.	0.34	0.1	0.15
CI-2252	4723	422	4473	928	59	762	0.2	0.14	0.14
SRCPX80AB2806	5362^{b}	572	5542.	245	67	1563	0.4	0.12	0.12
CV%	17.	6.		9.4	15.		23	16.	
Variety(13)	***	***		***	**		**	***	
Year(1)	***	***		***	**		**	***	
VarietyxYear(13)	***	***		***	**		**	***	

Simple correlation cofficient of growth, yield and yield components of oats varieties in 2016 and 2017 main crop growing season presented in table 4. The result showed that there was highly significant ($P<0.001$) positive correlation for plant height with days to flowering, biomass yield, panicle length and seed per spike. Whereas significant but negative correlation for plant height with tiller number, spike number, grain yield, thousand seed weight and harvest index. The positive significant relation of plant height with other growth and yield parameters reveals the true relation of parametrs and direct selection through this trait could be effective. Correlation analysis reveal highly significant ($P<0.001$) positive correlation for seed yield with tiller number per plant, spikelet number per plant, thousand seed weight and harvest index. Thus, those parameters are major contributors to seed yield since they have strong positive correlation. This result agrees with Dumlupinar et al (2012) and Sokoto et al (2012).

Table 4: Correlation analysis of growth, yield and yield components of Oats Varieties at Chencha (Ezo Ote), 2016&2017

	1	2	3	4	5	6	7	8	9	10
DTF	1									
PH	0.57***	1								
TN	-0.61**	-0.91**	1							
BMY	0.43**	0.84***	-0.75**	1						
PL	0.55***	0.95***	-0.91**	0.75***	1					
SN	-0.63**	-0.89**	0.92***	-0.73**	-0.88**	1				
SPS	0.57***	0.85***	-0.81**	0.74***	0.85***	-0.77**	1			
SY	-0.62**	-0.79**	0.79***	-0.57**	-0.79**	0.89***	-0.68**	1		
TSW	-0.67**	-0.93**	0.96***	-0.77**	-0.93**	0.95***	-0.83**	0.84***	1	
HI	-0.59**	-0.79**	0.84***	-0.68**	-0.78**	0.76***	-0.73**	0.56***	0.87***	1

Days to 50% flowering (DTF), Plant height (PH cm), Panicle Length (PL), Spikelet Number (SN), Seed Per Spike (SPS), 1000 Seed Weight (TSW), Seed yield (SY kg ha^{-1}), Biomass yield (BMY kg ha^{-1}) and Harvest index (HI)

Conclusion

Fourteen oat genotypes were evaluated for seed yield and yield components during 2016 and 2017 main cropping season at Ezo Ote, Southern Ethiopia. Based on the result of the study, ILRI-15153A proved to be superior genotype with respect to getting consitently higher biomass yield in the study area. In seed production, oat genotype CI-8233 found to produce better yield and closely followed by ILRI-5527A, CI-8251 and ILRI-5526A. Therefore, the mentioned genotypes here could be recomended to be the best technology options for seed production in the study area and similar agro-ecology for improved forage production in low-input crop-livestock farming system of Southern Ethiopia.

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