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Full-Length Research Article

Ezo_ote (ILRI_5527A): Registration of High-Yielding Dual Purpose Oat Variety for Ethiopian Agriculture

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ABSTRACT

The forage dry matter, seed yield, and fodder quality were found to be far below their potential in Ethiopia. One possible reason may be the limited availability of stable, high-yielding quality forage varieties in the mid- and highlands of the country. A field study was conducted to assess and introduce stable, high-yielding, and disease-resistant oat varieties. Eleven genotypes were compared at four locations (Arba Minch, Areka, Bonga, and Hawassa) during the 2018 and 2019 cropping seasons. Then, the performance of Ezo_ote (ILRI_5527) was verified on farms and on-stations and compared with two standard checks (SRCPX80AB2806 and SRCPX80AB2291) during the 2020–2021 main cropping seasons. The Ezo_ote (ILRI_5527A) variety performed better in most agronomic traits than both standard checks. Ezo_ote (ILRI_5527A) had an average dry matter yield of 12.59 t/ha, a seed yield of 3.6 t/ha, and a crude protein yield of 1.48 t/ha. The yield advantages of dry matter yield, seed yield, and crude protein yield were 8% and 21%, 0% and 9%, and 22.12% and 77.78% over the SRCPX80AB2806 and SRCPX80AB2291 varieties, respectively. Moreover, the new variety had shorter days of flowering and forage harvesting, and was resistant to septoria net blotch and yellow rust diseases. Therefore, Ezo_ote was found to be a superior oat variety in the checks and other trial varieties. The National Variety Release Committee (NVRC) approved Ezo_ote (ILRI_5527A) as a dual-purpose crop variety for cultivation and research in mid to high altitudes of Ethiopia.

Keywords*: Ezo_ote, Avena sativa L, crude protein yield, dual purpose, ILRI_5527A*

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1. INTRODUCTION

Ethiopia is ranked fifth worldwide in cattle ownership and tenth in livestock ownership (MOA, 2022). However, the country's livestock productivity is hindered by insufficient fodder and is largely dependent on low-quality pastures and crop residues (Shapiro et al., 2015). This leads to a modest average milk yield of 1.48 liters per cow (MOA, 2022).

Oat (Avena sativa L.), which is extensively cultivated as a cereal crop, is primarily harvested for green fodder, hay, silage, and seeds (Singh, 2018). Oats serve not only as a significant food source for humans, but also as feed for livestock (Iannucci et al., 2016). In Ethiopia's highlands, oats thrive under rain-fed conditions with minimal inputs (Beyene et al., 2015). They are particularly well-adapted for feed production in cool, wet climates with low-fertility soils, outperforming other cereals (Marshall et al., 2013). Oats yield higher biomass, between 12.5-13.1 t/ha, in acidic soils (Atumo & Kalsa, 2020). They are also cultivated in winter, providing green forage during periods of scarcity (Winter 2015). Oat grain, a balanced concentrate, is included in the diets of poultry, cattle, sheep, and other livestock (Mehta et al., 2015). Remarkably, oat grains can yield up to 2.1 t/ha (Atumo & Kalsa, 2020), with higher yields reported in diverse growing conditions (Peltonen-Sainio et al., 2008).

Oat crops produce a range of products used in animal feed, human consumption, and industrial materials (Stevens et al., 2004). These products, obtained from various parts of the crop, can be collected at different stages of growth, such as whole crop silage, straw, grain, and grain by-products (Marshall et al., 2013). Oats are exceptionally nutritious, providing high-quality protein with a lower energy content, making them ideal for certain types of animal feed (Mengistu et al., 2016). However, the production of forage seeds has not received adequate attention in national research and development programs (Atumo & Jones, 2021). Importantly, mixtures of oats and vetch can yield a crude protein content of 17.0%, sufficient to support the growth of calves and milk production (Molla et al., 2018).

In southern Ethiopia, livestock production is challenged by a feed shortage amounting to 34.4 tons/year in dry matter (DM), 57.9% in crude protein (CP), and 62.6% in metabolizable energy (ME), according to FAO 2018. The agricultural sector has historically placed little emphasis on forage crop enhancement, resulting in a scant number of forage varieties being released and registered in Ethiopia, as reported by EAA in 2021. Nonetheless, there was a notable increase to 72 officially registered forage crop varieties in 2021 (36 grasses, 28 herbaceous legumes, and 8 browses) from just 29 varieties in 2011. These varieties represent a mere 4.94% of all crop varieties developed in Ethiopia over the 50-year tenure of the Ethiopian Institute of Agricultural Research (EIAR) since 1976. In contrast, improved oat varieties have been shown to yield a high dry matter output and could potentially nourish twice the number of animals per unit area compared to conventional fodder crops. Selecting oat varieties that are high-yielding, of optimum quality, disease-resistant, early-maturing, and suitable for stressed soil conditions is vital in regions like South Ethiopia, Sidama, Central Ethiopia, and Southwest Ethiopia. This paper aims to detail the performance of the newly released oat variety 'Ezo_ote', providing valuable insights for stakeholders involved in food and forage oat production in Ethiopia.

2. MATERIALS AND METHODS

2.1. Description of study areas

The study was conducted during June 2018 through March 2020 *Belg* cropping season at Ezo ote, Gamo South Ethiopia (Arba Minch Agricultural Research Center (AMARC); Doyogena, Kembata Central Ethiopia (Areka Research Center); Adiyio, Kefa South West Ethiopia (Bonga Research Center); and Hula, Sidama Region (Hawassa Research Center) highland areas. Ezo oe at Arba Minch Research Center located at $6^0$18’32’ N, $37^0$33’E and altitude 2985 meter above seas level with an annual rainfall 1857.9 mm, minimum temperature 15.6^0C and maximum temperature 26.3^0C. the soil pH of Ezo Ote is 4.8 with textural class of clay loam (Atumo & Kalsa, 2020). Doyogena at Areka Research Center located at $7^0$21’68’ N, $37^0$47’E and altitude 2535 meter above seas level with an annual rainfall 1823.13 mm, minimum temperature 13.98^0C and maximum temperature 24.49^0C. The soil pH of Doyogena is 6.5 with textural class of clay loam (Abebe, 2014). Adiyio at Bonga Research Center located at $7^0$17’361’’ N, $36^0$22’00’’ E and altitude 2473 meter above seas level with an annual rainfall 2042.4 mm, minimum temperature 14.1^0C and maximum temperature 23.1^0C. The soil pH of Adiyio is 5.2 with textural class of clay loam (Wodebo et al., 2023). Hulla at Hawassa Research Center located at $6^0$27’001’’ N, $38^0$34’ E and altitude 2100 meter above seas level with an annual rainfall 1200 mm, minimum temperature 11.2^{0}C and maximum temperature 18.2^{0}C. The soil pH of Hulla is 6.0 with textural class of clay (Teramage et al., 2023). The study area map (Figure 1) also illustrates the geographical locations of the sites.

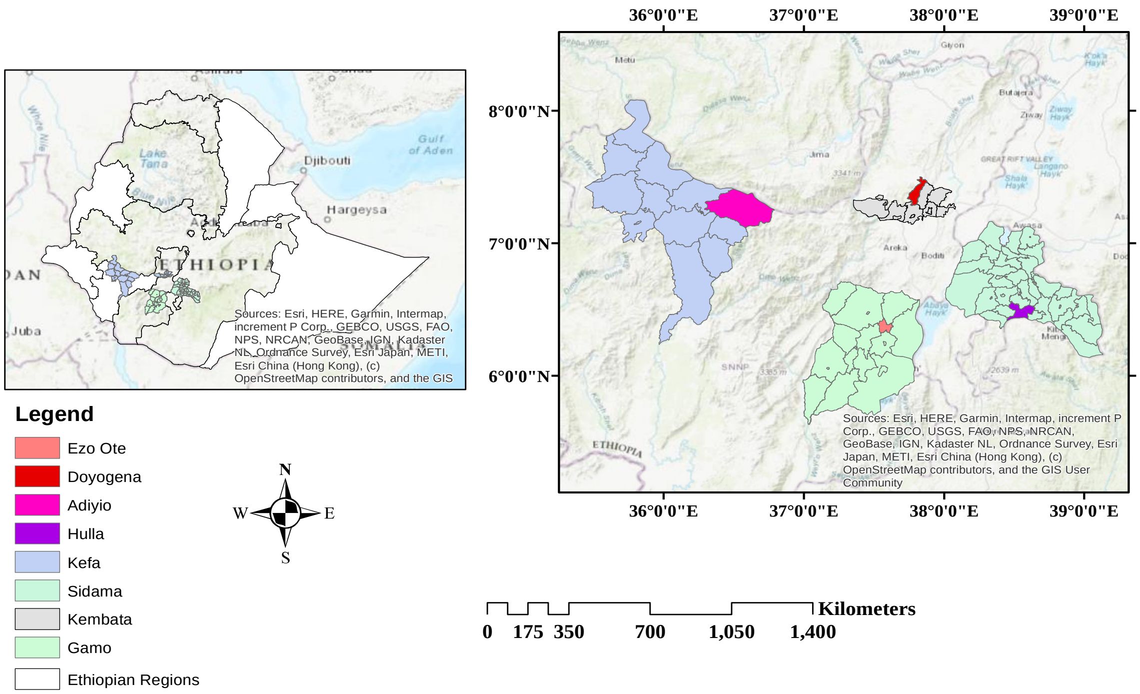

Figure 1: Study area map

2.2. Experimental units and designs

The experiment consisted of 11 treatments of oat genotypes namely ILRI-5431A, ILRI-5444A, ILRI-5490A, ILRI-5499A, ILRI-5526A, ILRI-5527A, ILRI-15152A, ILRI-15153A, ILRI-16101A, SRCPX80AB2291 and SRCPX80AB2806 which were laid out in randomized complete block design with three replications on well prepared and leveled field at four regions (South Ethiopia, Central Ethiopia, South West Ethiopia and Sidama) of the country. All the treatments were randomly allocated to different plots in each replication. Nine accessions from international livestock research institute (ILRI) were selected in consultation with the ILRI gene bank manager based on previous experience and consideration of which accessions may be most suitable to perform in the selected environment and the other two varieties were recently released at Holeta Agricultural research center used as standard check. The seed was sown in 10 rows of 3x2 m plot lines 20 cm spacing using drilling method in each location from Early July to mid-July each year. Rows were 3 meters long and blocks were spaced 1.5 meter apart. The seed rate used was 100 kg/ha. Blended fertilizer (NPS

100 kg/ha) of nitrogen, phosphorus and sulfur at the rate of N19%, P38% and S7% was applied with 50% of urea (50 kg/ha) applied at planting while the remaining 50% urea at mid-tillering of the crop. All relevant agronomic and quality data was collected from the four middle rows, seed data was from the rest four rows and the two rows were served as a border.

2.3. Origins of the genotypes under evaluation

The history of eleven oats genotypes presented in Table 1. Nine oats accessions were originated from United States of America and stored in the repository of ILRI forage gene bank. Other two varieties listed under number 10 and 11 are the oat varieties released by Holeta Agricultural Research Center (HARC) in 2015. The breeder seed of those varieties/ genotypes were maintained at their respective breeding center or gene bank.

Table 4: Origin, Other Name, DOI, Seed Source and Year of Release of the Genotypes used under National Variety (NVT) Evaluation

No.	Genotype/ Accession #	Other Name	Origin	DOI	Seed source		Year of release
					Gene bank	Breeder center	
1	15152	'Moore'	-	10.18730/FTEFF	ILRI	-	-
2	15153	'Saia'	-	10.18730/FTEGG	ILRI	-	-
3	16101	-	-	10.18730/FVA19	ILRI	-	-
4	5431	IFAV 189	USA	10.18730/G53JF	ILRI	-	-
5	5444	IFAV 291	USA	10.18730/G540X	ILRI	-	-
6	5490	IFAV 346	USA	10.18730/G55K6	ILRI	-	-
7	5499	IFAV 358	USA	10.18730/G55WF	ILRI	-	-
8	5526	IFAV 421	USA	10.18730/G56T8	ILRI	-	-
9	5527 (***Ezo_ote***)	IFAV 422	USA	10.18730/G56V9	ILRI	AMARC	2022
10	SRCPX80AB2291	-	-	-	-	HARC	2015
11	SRCPX80AB2806	-	-	-	-	HARC	2015

2.4. Variety evaluation procedures (NVT)

Preliminary yield trial was conducted during 2016 and 2017 for nine accessions collected from ILRI forage gene bank and five released varieties to select for high dry matter and seed production in Ethiopia production season (Atumo & Kalsa, 2020). During 2018 and 2019 national variety evaluation (NVT) was conducted for nine accessions aside to two standard check varieties at four locations.

Therefore the genotypes were exposed to be evaluated under eight (four by two) environments. According to the Ethiopian crop variety register guideline (MOA, 2000), after selecting superior candidate ILRI_5527A genotype, officially communicate with Ethiopian Agriculture Authority for variety verification at field level by assigning verification technical committee. Depending on the report from the compiling center National Variety Release Committee Variety release Form 1 filled and submitted to the former Plant Variety Release, Protection and Seed Quality Control Directorate under Ministry of Agriculture and Natural Resources now Ethiopian Agriculture Authority.

2.5. Variety verification procedures (VVT)

Based on the overall performances, the one better-performing oat variety (Ezo_ote/ILRI_5527) was promoted to a variety verification trial with two recently released checks SRCPX80AB2291 and SRCPX80AB2806. The four locations were at Arba Minch, Areka, Bonga and Hawassa Agricultural Research Centers during the main cropping season in 2021. The variety verification specific sites were Kemba and Ezo Ote (Arba Minch research center), Doyogena (Areka research center), and Alargeta (Bonga research centers) during 2021. In 2021 main cropping season, ILRI-5527A as candidate variety *Ezo_ote(ILRI_5527A)* along with SRCPX80AB2806 and SRCPX80AB2291 as standard check varieties was planted in the locations of NVT under on farm and on station condition in eight environments for variety verification (VVT). Each variety was planted in 10 m by 10 m (100 m^2) plot as to the standard of National variety releasing guideline (EAA, 2021). The national technical committee (TC) of National Variety Release (NVRC) observed and evaluated the variety in the field condition. ILRI-5527A is the traditional cultivar/landrace of USA found in the repository of ILRI forage gene bank (Table 2). As presented in Figure 1, the ILRI-5527A accession was found to be superior to the existing oat varieties for yield (dry matter, seed and crude protein), forage quality and other desirable agronomic traits.

The varieties were planted in rows of 25 cm apart on a plot size of 10 m by 10 m with a seeding rate of 100 kg/ha. At sowing, the recommended rate of DAP fertilizer was uniformly applied on the plots at each location. Other recommended cultural practices were also applied. The National Variety Release Committee (NVRC) evaluated the varieties at field (Figure 2) conditions and based on their evaluation result, the variety Ezo_ote/ILRI_5527A was approved for cultivation in April 2022 to be utilized by various end-users.

Figure 2: Field Performance of New Oats Variety at Verification in the Study Areas

2.6. Data collection

The plant height (PH cm) was measured using tape centimeter graduated meter for selected sample plants from ground to top of the plant at leaf end and panicle initiation begin. Dry matter yield (DMY t/ha) was computed by collecting 300 gram fresh sample from the four central rows at 50% flowering and dried under shade air to constant weight and using the formula: DMY(t/ha)=DM% x FMY (DM%=Dried sample/fresh sample x 100). Leaf to stem ratio (LSR) was calculated by dividing leaf dry matter to stem dry matter yield. Seed yield (SY t/ha): at harvest maturity, plants from the remaining four central rows were cut to 30 cm above ground level, seeds were threshed and dried in the shade to a constant weight to calculate the seed yield. Seeds were weighed in a senstive balance and the yield converted to a per hectare base using the formula SY (t/ha) = SYPP*0.3, where SY is seed yield per hectare and SYPP is the seed yield for four rows. Forage nutritional quality, in terms of ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) concentration, was tested in the laboratory according to National Forage Testing Association (NFTA) procedures (Paine et al., 1999).

2.7. Data analysis

The data generated were statistically analyzed using the analysis of variance procedure and least significance difference, at the 5% probability level, of Genstat statistical sofware (version 16, VSN International LTD, UK) (Payne et al., 2015).

3. RESULTS AND DISCUSSION

3.1. Agronomic and morphological characteristics

As presented in Table 2, the longest plant height was observed for the genotype ILRI_15153A (144.84 cm) followed by ILRI_15152A (142.25 cm). The height of standard check varieties SRCPX80AB2291 and SRCPX80AB2806 were 126.48 and 139.02 cm, respectively. The newly released variety Ezo_ote demonstrated the average plant height of 127.85 cm while the shortest plant in the experiment was ILRI_5499A with the height of 124.72 cm (Table 3). ILRI_15153 and SRCPX80AB2806 had higher leaf number per plant of 4.4 and 4.3 leaves per plant, respectively while the average leaf number of the newly released variety Ezo_ote was 3.9. There was no significant (P>0.05) variation observed for leaf to stem ratio of genotypes tested over location during 2018 and 2019 (Table 3). The new variety Ezo_ote(ILRI_5527A) (0.435), however, produced a higher leaf to stem ratio over the standard check SRCPX80AB2806 (0.375) and SRCPX80AB2291 (0.371)) with an advantage of 16.8% and 17.1%, respectively.

Table 5: Average Plant Height of Oat Varieties Planted at Four Locations of Ethiopian Regions during 2018 And 2019 Cropping Seasons

Genotype	Arba Minch	Areka	Bonga	Hawassa	Mean
ILRI_15152A	79.1bc	133.83	176.8ab	111g	142.25ab
ILRI_15153A	113.2a	146	154.5bc	135b	144.84a
ILRI_16101A	99.9ab	155.67	186.2a	115f	132.45cd
ILRI_5431A	117.25a	149.5	160.4bc	142a	128.56d
ILRI_5444A	66.45c	132	168.1abc	110g	134bcd
ILRI_5490A	119.95a	135.17	146.1c	106.3h	132.91bcd
ILRI_5499A	99.65ab	128.33	174.4ab	122.3e	124.72d
ILRI_5526A	98.2ab	127.33	158.9bc	130c	126.32d
ILRI_5527A (Ezo_ote)	78.6bc	130.17	148.2c	126d	127.85d
SRCPX80AB2291	94.6abc	117.83	156.8bc	117.3f	126.48d
SRCPX80AB2806	85.1bc	145	175.7ab	106h	139.02abc
Mean	95.63	136.439	164.19	120.09	132.67
CV%	25.5	9.7	8.9	6.5	8.8
$LSD_{0.05}$	39.8	NS	24.87	14.1	18.89

NB: different letters in a column are indicating significant (P<0.05) difference among genotypes, CV% coefficient of variation, LSD is least significant difference at 5% probability level.

The newly released variety of oats, Ezo_ote, is an annual herbaceous grass type dual purpose crop which can be characterized by its agronomic and morphological characteristics. The maximum plant height of Ezo_ote oat variety at 50% flowering, forage harvesting stage was 176.8 cm. The newly released variety was attained 85-92 days to flowering, the maximum days to forage harvesting (50% flowering) at 115 days while the standard checks SRCPX80AB2291 and SRCPX80AB2806 121 and 147 days after planting. The seed harvesting of newly released variety took 160 days while the checks 165 and 169 days, respectively. This indicates the newly released oat variety can be characterized as early maturing type when comparing to SRCPX80AB2806 and SRCPX80AB2296 varieties. The white seed colored and long seed sized newly released variety exhibited a hundred seed weight of 39.33 gram which is higher than the hundred seed weight of SRCPX80AB2806 (30 gram) while comparable with the hundred seed weight of SRCPX80AB2296 (39.33 gram). The harvest index (0.17) of newly released variety was by far better than the harvest index of both checks. Panicle length and spikelet number of the newly released variety were superior over the check variety SRCPX80AB2806 but comparable with SRCPX80AB2296. The white colored new variety with easy threshing ability with stands lodging better than both checks. According to the lodging assessment at VVT, newly released variety Ezo_ote was exposed to lodging by 5% while SRCPX80AB2296 25% and SRCPX80AB2806 15% especially at Doyogena and Kemba.

Table 6: Average Leaf Number per Plant (LNPP) and Leaf to Stem Ratio (LSR) of Oat Varieties Planted at Four Locations of Ethiopian Regions during 2018 And 2019 Cropping Seasons

Genotype	LNPP			LSR		
	2018	2019	Mean	2018	2019	Mean
ILRI_15152A	3.5	4.1	3.8^{abc}	0.26	1.99	1.13
ILRI_15153A	4.7	3.9	4.3^{a}	0.49	0.51	0.5
ILRI_16101A	3.1	3.9	3.5^{bc}	0.48	1.69	1.09
ILRI_5431A	3.7	3.6	3.6^{bc}	0.47	1.28	0.88
ILRI_5444A	4.9	3.3	4.1^{ab}	0.78	1.15	0.96
ILRI_5490A	4.3	4	4.1^{ab}	0.62	0.94	0.78
ILRI_5499A	3.7	3.9	3.8^{abc}	0.56	1.24	0.9
ILRI_5526A	3.3	4.3	3.8^{abc}	0.54	1.77	1.15
ILRI_5527A (Ezo_ote)	3.6	4.1	3.9^{abc}	0.57	1.37	0.97
SRCPX80AB2291(SC)	4	2.6	3.3^{c}	0.49	0.84	0.67
SRCPX80AB2806(SC)	4.3	4.4	4.4^{a}	0.37	1.26	0.81
Mean	3.9	3.8	3.9	0.51	1.28	0.89
	CV%=14.1 $LSD_{0.05}$=0.64			CV%=48.3 $LSD_{0.05}$=NS		

NB: different letters in a column are indicating significant ($P<0.05$) difference among genotypes, CV% coefficient of variation, LSD is least significant difference at 5% probability level.

Ezo_ote(ILRI_5527A*)* variety had higher number of tiller, leaf to stem ratio, plant height, and straw to grain ratio, dry matter, seed and crude protein yield. The variety was better resistant to yellow rust and septoria net blotch than standard checks (SRCPX80AB2806 and SRCPX80AB2291) during variety evaluation and verification. The newly released variety was superior in terms of crude protein (117.6 g/kg DM) quality in gram per kilogram dry matter over both check (103.7 and 80 g/kg DM) varieties. The variety was characterized by its low ash, NDF, ADF and ADL content when compared to both check varieties.

The newly released oat variety was adapted to mid to higher altitudes ranging from 1800-3000 meters above sea level with an annual rainfall ranging from 1200-2042 mm. Ezo_ote, new oat variety had good performance under nitosol and clay loam soil types. The new variety should be sown early to mid-July with a seeding rate of 100 kg ha^{-1} at 25 cm row spacing. At planting, the application of the recommended rate of DAP and Urea (at planting and at tiller initiation stage) fertilizers enhances the establishment performance of oat variety. The agronomic and morphological characteristics of the released oat variety are presented in Table 4 below.

Table 7: Morpho-Agronomic Characteristics of Ezo_Ote(ILRI_5527A) Dual Purpose Oat Variety Comparing to Two Standard Check Varieties

Variable	Description		
Variety name	***Ezo_ote(ILRI_5527A)*** (Acc#ILRI-5527)	SRCPX80AB2806 (Standard Check)	SRCPX80AB2291 (Standard Check)
Agronomic and morphological characteristics:			
Adaptation area	Mid to highlands of southern, south western, southeastern and other similar ago ecological zones of Ethiopia		
Altitude (meter above sea level)	1800-3000		
Rainfall (mm)	1200-2042		
Temperature (^{0}C) Max/Min	23.11-26.28/13.98-15.57		
Seed rate (kg/ha)	100		
Planting date	Early to Mid-July depending on the moisture status of location		
Spacing (cm)	20 cm between rows for seeds drilled in the rows		
Fertilizer rate (kg/ha): P_2O_5	23		
N	23 (1/2 at planting and ½ at tiller initiation stage)		
Days to flowering	85-92		
Days to forage harvesting	92-115	133-147	112-121
Days to seed harvesting	155-160	155-165	155-169
Plant height at forage harvest (cm)	85.07-175.73	113.23-154.53	79.07-176.8

Variable	Description		
Variety name	***Ezo_ote(ILRI_5527A)*** (Acc#ILRI-5527)	SRCPX80AB2806 (Standard Check)	SRCPX80AB2291 (Standard Check)
Leaf to stem ratio	0.435	0.371	0.371
1000 seed weight (g)	39.33	30	39.33
Harvest index	0.17	0.12	0.11
Panicle length (cm)	24.67	24.07	24.93
Spikelet number	21.13	17.73	21.8
Seed color	White		
Straw to grain ratio	4.321	3.55	3.11
Thresh ability	Easy		
Lodging incidence	Moderately resistant		
Crop pest reaction (1-5):	Resistant to septoria net blotch and yellow rust		
Forage quality (g/kg DM)			
CP	117.6	103.7	80
Ash	47.9	48.2	51.5
NDF	470.1	526.1	548.7
ADF	318.5	389.7	386.5
ADL	85.7	100.9	98
Yield (t/ha)			
Forage dry matter	12.59	11.67	10.38
Seed	3.59	3.6	3.3
Straw	8.64	5.54	6.42
Crude Protein	1.45	1.21	0.83
Year of release	2022		
Breeder/maintainer	Arba Minch Agricultural Research Center/SARI		

3.2. Yield performance in different environmental locations

3.2.1. Dry matter yield (DMY)

The newly released oat variety is a dual purpose which can be used for animal feed as well human food. Dry matter yield of the new variety and its standard checks were presented in Figure 2. Ezo_ote (ILRI_5527A) was produced a higher mean dry matter yield (12.59 t/ha) in six environments than SRCPX80AB2806 (11.67 t/ha) and SRCPX80AB2291 (10.38 t/ha) during the evaluation season. The higher dry matter yield was produced at Bonga (2019=19.5, 2018=13.78 t/ha) followed by Areka (2019=13.98, 2018=7.42 t/ha) and Arba Minch (2018=8.29, 2019=6.76 t/ha).

The average dry matter yield of oat varieties in testing environments presented in Table 5. The mean dry matter yield performance of oats varieties ranged from 10.38 to 14.05 t/ha with a mean of 11.62 t/ha across the test environments. The highest mean dry matter yield was recorded for IRLI_15153A followed by Ezo_ote (ILRI_5527A) and ILRI_5526A, while SRCPX80AB2291and SRCPX80AB2806 gave the lowest dry matter yield across the environments. The rank of the varieties for dry matter yield was different across the test environments which are indicating the effect of genotype by environment interaction on dry matter yield performances of the oat varieties.

Concerning the yield advantage of dry matter, Ezo_ote/ILRI_5527A, newly released variety, had a yield advantage of 10.54% and 24.28% over check varieties SRCPX80AB2806 and SRCPX80AB2291, respectively.

The current result on dry matter yield for newly released variety, Ezo_ote 12.59 t/ha, was by far better than Gadisa et al., (2023) who reported a combined dry matter yield performance range of 6.2 to 9 t/ha in Eastern Oromia but closely comparable with Gezahagn et al., (2021) who reported an oat dry matter yield ranging from 11.5 to 15.6 t/ha in central highlands of Ethiopia. Hence, the performance of dry matter yield of oat genotypes was significantly affected by the genetic, environmental, and their interaction effects.

Table 8: Average Dry Matter Yield of Oat Varieties across Location over Years

Genotypes	AM18	AM19	Ar18	Ar19	Bn18	Bn19	Genotype Mean
ILRI_15152A	6.578d	7.19bc	8.73	15.49	12.23cd	22.11a	12.05
ILRI_15153A	12.565a	9.469ab	8.10	15.00	15.64bc	23.55a	14.05
ILRI_16101A	9.895abc	6.409bc	7.27	12.48	11.21d	19.15abcd	11.07
ILRI_5431A	7.913bcd	7bc	6.93	13.60	12.81cd	17.05cd	10.44
ILRI_5444A	6.471d	6bcd	7.60	15.83	11.83d	21.7ab	11.37
ILRI_5490A	6.584d	6.34bc	4.37	11.40	11.53d	22.65a	10.48
ILRI_5499A	7.757bcd	6.246bc	6.57	12.94	17.06b	17.27bcd	11.31
ILRI_5526A	8.805bcd	11.425a	8.70	16.91	14.14bcd	14.54d	12.42
ILRI_5527A (Ezo_ote)	7.586bcd	7.897abc	8.13	13.16	22.07a	16.69cd	12.59
SRCPX80AB2291	7.038cd	2.138d	6.40	13.78	12.29cd	20.64abc	10.38
SRCPX80AB2806	9.983ab	8.084abc	8.83	13.22	10.73d	19.15abcd	11.67
Environment mean	8.29	6.76	7.42	13.98	13.78	19.50	11.62
$LSD_{0.05}$	2.877	3.91	NS	NS	3.80	4.61	
CV%	20.4	18.3	23.30	19.60	16.20	13.90	

NB: AM Arba Minch, Ar Areka, Bn Bonga, 18 and 19 are 2018 and 2019; different letters in a column are indicating significant (P<0.05) difference among genotypes, CV% coefficient of variation, LSD is least significant difference at 5% probability level.

3.2.2. Seed yield (SY)

The average seed yield and its advantage of newly released oat variety, Ezo_ote, presented in Table 6 below. The seed yield performance of oat genotypes varied significantly (P<0.05). The seed yield variation among oat genotypes was ranging from 2.61 to 3.87 t/ha in the present study. The highest seed yield was obtained from the genotype ILRI_15153A followed by ILRI_15152 which was not significantly varied with newly released variety and the check SRCPX80AB2806. The lowest seed yield was for ILRI_16101A genotype in the present evaluation. The average seed yield of 3.6 t/ha produced by Ezo_ote/ILRI_5527A was superior over the check variety SRCPX80AB2291 with a yield advantage of 9%. However, the seed yield of newly released variety, Ezo_ote, was closely similar and comparable with another check SRCPX80AB2806 in the present experiment.

The previously reported seed yield of check varieties SRCPX80AB2291 2.76 t/ha and SRCPX80AB2806 3.21 t/ha (Gezahagn et al., 2021) was lower than the performance of current evaluation for each 3.29 t/ha and 3.6 t/ha, respectively. This may be due to the environment advantage for the high yielding. Beyene et al., (2015) reported high variation of seed yield among different oats varieties. The seed yield of 3.64 t/ha for oats which has been reported by (Singh, 2018) was closely comparable with the seed yield of recently released variety. The new variety was also recommended for higher seed yield and optimum dry matter in the preliminary yield trial (Atumo & Kalsa, 2020). Therefore, the performance of seed yield of oats was significantly affected by the genetic factors, environmental factors, and interaction of genotype and environment.

3.2.3. Crude Protein Yield (CPY)

The average crude protein yield and its advantage over check varieties is presented in Table 6. The crude protein yield of oats genotypes was varied significantly (P<0.05) among genotypes. The crude protein yield variation among oats genotypes was ranging from the lowest yield of 0.83 t/ha for a check variety SRCPX80AB2291 to 1.48 t/ha for the newly released oats variety Ezo_ote. Ezo_ote/ILRI_5527A variety gave higher mean crude protein yield of 1.48 t/ha than SRCPX80AB2806 (1.21 t/ha) and SRCPX80AB2291 (0.83 t/ha). The advantage of crude protein yield of Ezo_ote was 22% over SRCPX80AB2806 while 78% over SRCPX80AB2291 check variety. This may indicate approving the newly released variety to be registered and released in the tested locations and similar ecologies would have an advantage of growing calves, rearing milking cows, oxen and other livestock species.

Table 9: Average Seed Yield (SY T/Ha), Crude Protein Yield (CPY T/Ha) and Yield Advantages of Newly Released Oat Variety (Ezo_Ote) over Checks in the Evaluation

Genotypes	SY t/ha	Yield advantage over Checks		CPY t/ha	Yield advantage over Checks	
		SRCPX80-AB2806	SRCPX80-AB2291		SRCPX80-AB2806	SRCPX80-AB2291
ILRI_15152A	3.85a	7%	17%	1.21b	0%	46%
ILRI_15153A	3.87a	7%	18%	1.07c	0%	29%
ILRI_16101A	2.61c	0%	0%	1.06c	0%	28%
ILRI_5431A	3.19b	0%	0%	0.89d	0%	7%
ILRI_5444A	3.28b	0%	0%	1.15c	0%	39%
ILRI_5490A	3.61ab	0%	10%	1.03c	0%	24%
ILRI_5499A	3.16b	0%	0%	1.13c	0%	36%
ILRI_5526A	3.10b	0%	0%	1.29b	7%	55%
ILRI_5527A (Ezo_ote)	3.59ab	0%	9%	1.48a	22%	78%
SRCPX80AB2291	3.29b	0%	0%	0.83d	0%	0%
SRCPX80AB2806	3.60ab	0%	10%	1.21b	0%	46%
Mean	3.38			1.12		
LSD0.05	0.5	-	-	0.15	-	-
CV%	12.6	-	-	11.2	-	-

NB: different letters in a column are indicating significant ($P<0.05$) difference among genotypes, CV% coefficient of variation, LSD is least significant difference at 5% probability level.

3.3. Reaction to major diseases

The released Ezo_ote variety was tested for diseases and pests reaction starting from the initial stage of evaluation to verification stage and found to be resistant to major diseases and pests which can affect the varieties as presented in Figure 3. The diseases and pest effects on the performance of oats varieties were recorded as 0-10% resistant, 11-30% moderately resistant, 31-60% moderately susceptible, and 61-100% susceptible. It was scored using the procedure of Peterson et al., (1948) modified cob rating scale for yellow rust by a diagrammatic scale for estimating rust intensity on leaves and stems of cereals. Yellow rust and septoria net blotch were the important diseases occurred during the variety evaluation and verification process of the varieties. *Ezo_ote(ILRI_5527A)* was found to be resistant to yellow rust diseases of oats when compared to both check varieties in the evaluation. The variety *Ezo_ote(ILRI_5527A)* was also resistant to Septoria net blotch disease compared to standard checks in the variety evaluation trial. In similar year (2018) with the variety evaluation, the experimental sites especially Chencha and Bonke area were reported for yellow rust and stem rust stress tempting the production of wheat crops (Mengesha, 2020). The resistance reaction of newly released oat variety could be integrated with other diseases and pest management strategies for better results. Therefore, the released oat variety could be superior in tolerance to major diseases and pests when compared to both standard check varieties.

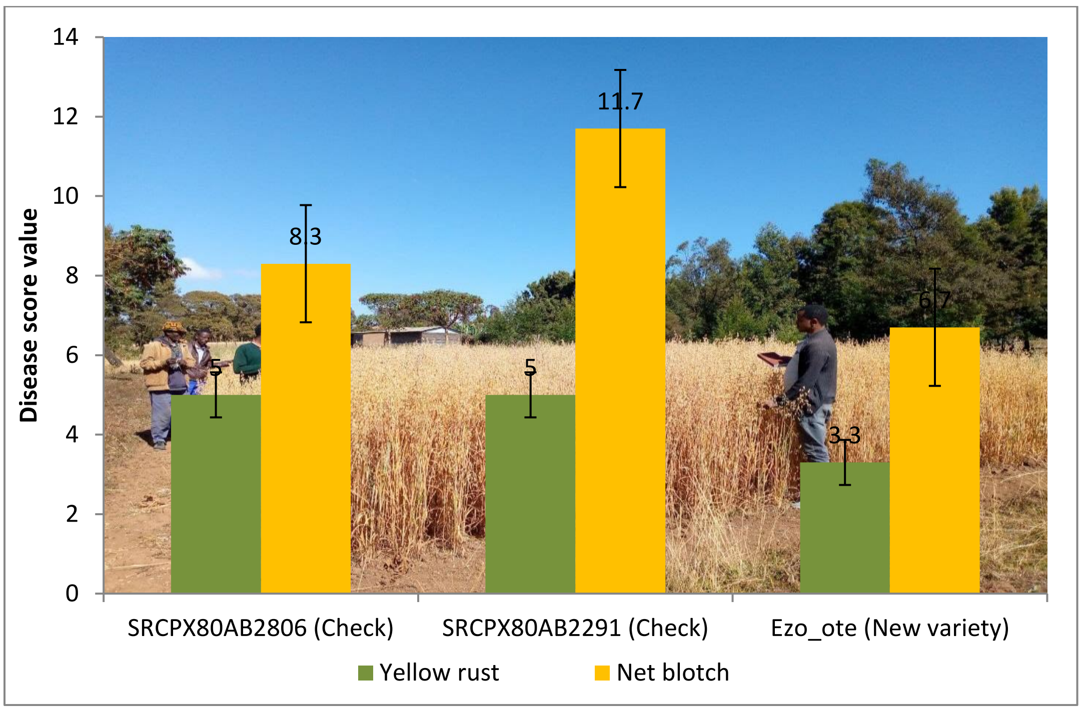

Figure 3: Yellow Rust and Septoria Net Blotch Diseases Reaction of Ezo_Ote (ILRI_5527A) Variety Comparing with Standard Checks during Variety Evaluation; scoring values 0-10% resistant, 11-30% moderately resistant, 31-60% moderately susceptible, and 61-100% susceptible

3.4. Forage quality analysis

The concentration in gram per kilogram dry matter of forage quality parameters of the new variety (*Ezo_ote*) and standard checks in terms of crude protein, acid detergent fiber, neutral detergent fiber, acid detergent lignin and ash is presented Table 7. New variety demonstrated higher concentration of crude protein with lower concentration of neutral detergent fiber, acid detergent fiber and lignin than both standard check varieties in the trial.

As presented in Table 9, the newly released variety, Ezo_ote had higher CP, but lower ash and fiber contents than the check varieties. However, the variation in ash content among oats genotypes was not significant (P>0.05), the ash composition of Ezo_ote was as lowest as 47.9 g/kg DM. The released oat variety Ezo_ote gave the highest CP concentration of 117.6 g/kg DM. The lowest NDF, ADF and ADL composition was recorded for Ezo_ote, newly released variety, with the value of 470.1 g/kg DM, 318 g/kg DM and 85.7 g/kg DM, respectively, when compared to check varieties and other genotypes in the evaluation. The crude protein advantage of newly released oat variety, Ezo_ote, over check varieties SRCPX80AB2291 and SRCPX80AB2806 were 47% and 13.4%, respectively.

Crude protein (CP) value of Ezo_ote variety was 117.6 g/kg DM. This value is higher for oat varieties that (Gadisa et al., 2023) reported CP value ranging from 96 to 102.1 with a mean of 99.3 g/kg DM for 15 genotypes, (Gezahagn et al., 2021) 69 to 81 with a mean of 77 g/kg DM for 15 genotypes. Moreover, the recently released variety, Ezo_ote, was superior on crude protein composition over the check varieties at present evaluation and the value at time of releasing for the checks (EAA, 2021).

Average value of Acid detergent fiber (ADF) composition of Ezo_ote variety was 318.5 g/kg DM. This value is lower than the result of (Gadisa et al., 2023) who reported the ADF value of oat genotypes ranging from 628 to 686 g/kg DM with the average composition value of 651.7 g/kg DM. When compared to the present ADF composition value of Ezo_ote variety, another scholar (Gezahagn et al., 2021) also reported the higher ADF composition ranging from 454 to 520 g/kg DM with the mean value of 485 g/kg DM. The present ADF value 318.5 g/kg DM concurs with the ADF value 313 to 383 g/kg DM reported at variety releasing of Bonsa and Bona-bas oats variety for Bale highlands of Ethiopia (Abate & Wegi, 2011).

Table 10: Average Chemical Composition (g/kg DM) of Oat Varieties at Different Locations 2018-2019

Genotype	ADF	ADL	Ash	CP	DM	NDF
ILRI_15152A	415.5^{a}	104.6	44.8	100.1^{b}	966.7	559.6^{a}
ILRI_15153A	398.8^{ab}	102.7	42.5	76.1^{c}	940	526.1^{abc}
ILRI_16101A	361.4^{abc}	87.7	51.9	96.1^{b}	963.3	513.3^{abcd}
ILRI_5431A	344.7^{bcd}	84.2	51.9	84.8c	960	484.1^{cd}
ILRI_5444A	369.6^{ab}	91.6	58.2	101.4^{b}	973.3	505.9^{abcd}
ILRI_5490A	365.2^{abc}	96.2	48.1	98.1^{b}	970	492.3^{bcd}

Genotype	ADF	ADL	Ash	CP	DM	NDF
ILRI_5499A	348.0^{bcd}	87.9	51.9	99.6^{b}	966.7	472.0^{cd}
ILRI_5526A	300.5^{d}	79.5	48.8	104.1^{b}	956.7	455.8^{d}
ILRI_5527A (Ezo_ote)	318.5^{cd}	85.7	47.9	117.6^{a}	973.3	470.1^{cd}
SRCPX80AB2291	386.5^{ab}	98	51.5	80.0^{c}	970	548.7^{ab}
SRCPX80AB2806	389.7^{ab}	100.9	48.2	103.7^{b}	966.7	526.1^{abc}
Mean	365	92.6	49.6	96.5	964.2	504.9
CV%	12.5	15.7	21.1	11.2	2	9.8
$LSD_{0.05}$	3.8	NS	NS	0.92	NS	4.2

4. CONCLUSION AND RECOMMENDATIONS

The results of the present study have confirmed that *Ezo_ote(ILRI_5527A)* variety demonstrated a high dry matter, seed and crude protein yield, resistant to yellow rust and septoria net blotch diseases. Moreover, the variety has lower fiber content such as neutral detergent fiber, acid detergent fiber, acid detergent lignin; early flowering, higher leaf to stem ratio, greater number of tillers per plant, harvest index and straw grain ratio.

Generally, the variety has traits preferred by farmers as confirmed by their positive feedback during the evaluation and verification trials. As the variety has been approved by the National Variety Release Committee (NVRC), it is possible to recommend the newly released variety for fodder and grain production. Based on the crude protein and dry matter production, the variety could be promoted for calves, milking cows, draft animals and other livestock species feed material. The seed yield is also optimum and recommended for grain production too. Hence, it is necessary to promote the newly released variety, Ezo_ote, in mid and highlands of south, southwestern and south eastern Ethiopia and similar agro-ecologies. Farmers, investors, government and non-government organizations, researchers, universities and other concerned entities could use the newly released variety, Ezo_ote, for their intended purposes in the tested and similar environments in Ethiopia and elsewhere.

Conflict of Interest:

The author(s) did not disclose any potential conflicts of interest

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