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Linseed Variety Development for Grain Yield and Oil Content for Potential Areas: Registration of “Filera” and “Keyeron” Linseed Varieties

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ABSTRACT

Linseed also known as flax seed is an important oil crop cultivated worldwide for oil and fiber. Fourteen Linseed genotypes were evaluated in a multi-location variety trial at Sinana and Agarfa to identify stable genotype with high grain yield, good quality, desirable agronomic characters, and a good level of disease resistance. Combined analysis result showed that genotypes ACC 230826 exhibited the highest mean grain yield potential with good agronomic performance and good level of disease resistance across testing environments, while genotype, EH010007-7 exhibited the highest Oil yield and Oil contents with good grain yield, good agronomic performance and a good level of disease resistance. Accordingly, the two varieties, ACC 230826 and EH010007-7 were promoted to variety verification trial in 2021, and released in 2022 under the name Filera and Keyeron, respectively. Both varieties showed good physical grain quality coupled with high grain yield potential of 2.4 and 2.48 t/ha, respectively. The two varieties have shown good levels of disease resistance to powdery mildew, pasmo, Wilt and good lodging tolerance. The linseed varieties Filera and Keyeron are well adapted to the highlands of Bale and other similar agroecological zones in Ethiopia. Their cultivation has the potential to enhance linseed production and productivity, thereby contributing to the alleviation of the country's chronic edible oil shortage while increasing the availability of raw material for domestic consumption and export markets.

Keywords: *Linseed, Variety Registration, Oil Content.*

1. INTRODUCTION

Linseed (*Linum usitatissimum* L.) is an important oilseed crop cultivated in temperate and highland agroecologies for its edible oil, industrial applications, and nutritional benefits. It is widely recognized for its high-quality oil rich in omega-3 fatty acids and its diverse uses in food and non-food industries [7, 10].

Globally, linseed is cultivated across Europe, Asia, North America, and parts of Africa, with production concentrated in countries such as Canada, Kazakhstan, China, and India. Recent FAO-based estimates indicate that global linseed production has ranged between approximately 2.6 and 4.0 million tonnes in recent years, depending on climatic variability and cropping area fluctuations [9, 12]. Despite its economic importance, global average yield remains relatively low, commonly ranging from 0.8 to 1.2 t ha^{-1} under smallholder and rain-fed systems, although yields exceeding 1.5–2.5 t ha^{-1} are achievable under improved management and mechanized production systems [9, 12].

In Ethiopia, linseed is one of the major oilseed crops grown predominantly in the highland regions between 1,800 and 3,000 m above sea level under rain-fed conditions. The country is considered one of the centers of diversity for linseed and ranks among the major global producers of the crop [6]. National production has shown gradual improvement over time, reaching more than 80,000 tonnes in recent years; however, productivity remains low, with an average yield of approximately 1.0–1.2 t ha^{-1} under farmers' conditions [2, 6].

These differences highlight the importance of improved genotypes combined with appropriate agronomic management for yield enhancement. Therefore, addressing these constraints requires the development and deployment of improved varieties with enhanced yield potential, oil quality, and stress adaptation. Accordingly, the objective of this study was to register stable, high-yielding, and good-quality linseed varieties adapted to the highland agroecologies of Bale and other similar environments.

2. Varietal Origin/Pedigree and Evaluation

The candidate linseed genotypes ACC 230826 and EH010007-7, subsequently released as Filera and Keyeron, respectively, were obtained from the Holeta Agricultural Research Center of the Ethiopian Institute of Agricultural Research (EIAR). These genotypes, together with other experimental entries and a local check, were evaluated under multi-environment trials conducted at Sinana and Agarfa over three consecutive main cropping seasons (2018–2020) to assess their agronomic performance, adaptability, and yield potential.

3. Agronomic and Morphological Characteristics

Some morpho-agronomic attributes and oil content analysis of Filera and Keyeron is illustrated in Table 1, 2, 3, and in detail in Table 4.

4. Grain Yield Potential, Stability, and Reaction to the Major Diseases

A total of fourteen linseed genotypes, together with two standard check varieties, were evaluated at Sinana and Agarfa during the 2018–2020 main cropping seasons using a randomized complete block design (RCBD) with four replications. The candidate genotypes ACC 230826 and EH010007-7 consistently and significantly outperformed the standard check varieties, Jitu and Dibane, across the test environments (Table 3). Based on their superior grain yield performance, adaptability, and agronomic merit, the two genotypes were released as the varieties Keyeron and Filera, respectively. Across all testing locations, Keyeron and Filera achieved mean grain yields of 2,480 and 2,417 kg ha^{-1}, respectively (Table 2). In addition to their high yield potential, both varieties exhibited desirable oil content, with Keyeron recording 43.67% and Filera 42.84%, further enhancing their value for linseed production and utilization (Table 1).

The major diseases affecting linseed production in the target growing areas are powdery mildew (*Oidium* spp.), pasmo (*Septoria linicola*), and Fusarium wilt (*Fusarium oxysporum*) (Getinet and Nigussie, 1997). Disease reaction was assessed using a 1–9 severity rating scale, where lower scores indicate greater resistance. Both Filera and Keyeron exhibited favorable disease responses, with a mean score of 3 for all three diseases, indicating moderate resistance under field conditions. Comparative disease severity scores for the released varieties and the standard check varieties are presented in Table 4.

Stability analysis based on the joint regression model of 3] revealed that the candidate genotypes exhibited high grain yield performance coupled with desirable stability parameters. Both genotypes showed regression coefficients (bi) not significantly different from unity and deviations from regression (S^2di) not significantly different from zero, indicating broad adaptation and stable performance across diverse environments.

The released varieties, Filera and Keyeron, produced mean grain yields of 2,480 and 2,417 kg ha^{-1}, representing yield advantages of 16.86% and 13.84%, respectively, over the standard check variety Jitu (Table 1). Owing to their superior yield performance and stability, both varieties were advanced to variety verification trials in 2021 and subsequently released for large-scale production in 2022.

5. Quality Analysis

Seed color and oil content are important quality attributes influencing variety acceptance by both producers and consumers. The light-yellow seeded variety Keyeron was particularly favored for its attractive seed color and high oil content. Laboratory analyses showed that Keyeron and Filera contained 43.67% and 42.84% oil content, respectively (Table 2), demonstrating their potential for enhanced oil yield and marketability.

6. Performance Stability and Adaptation Domain

The varieties Filera and Keyeron are recommended for cultivation in the highland areas of Bale, particularly at altitudes ranging from 2,300 to 2,600 m above sea level and under annual rainfall conditions of 750–1,000 mm. Their cultivation may also be extended to other regions with comparable agroecological conditions. Optimum grain yield can be achieved when the varieties are grown using the recommended fertilizer rate of 23 kg ha^{-1} P_2O_5 and 23 kg ha^{-1} N (Table 2). Stability analysis indicated that both Filera and Keyeron exhibited relatively stable and comparable performance across diverse test environments (Table 4).

Table 1: Morpho-agronomic and quality trait description of Filera and Keyeron

No	Agronomical and Morphological Characteristics		Keyeron (EH010007-7)	Filera (ACC 230826)
1	Adaptation area		Highlands of Bale: Sinana, Goba, Agarfa, Gassera, Adaba, Dodola) and other similar agro-ecologies	
2	Altitude (m.a.s.l.)		2300 – 2600	2300 – 2600
3	Rainfall (mm)		750 – 1000	750 – 1000
4	Seed Rate (Kg/ha)		25-30 (for row and broadcasting, respectively)	25-30 (for row and broadcasting, respectively)
5	Planting date		End of July	End of July
6	Fertilizer Rate (NPS kg/ha)		23/23	23/23
7	Days to Flower		67	69
8	Days to Maturity		146	145
9	Plant Height (cm)		90	93
10	1000 Seed Weight (gm)		5.9	5.1
11	Seed Color		Light yellow	Brown
12	Flower Color		Pink	Pink
13	Oil content (%)		43.67gm	42.84gm
14	Yield (Qt/ha)	(Research Field) Average of three years	19-22.5 on average= 21	20-26 on average= 23
		On-farm	15-18 on average = 16.5	16-19 on average = 17.5
15	Disease reaction		Tolerant to Powdery Mildew, wilt and pasmo	Tolerant to Powdery Mildew, wilt and pasmo
16	Yield advantage over Jitu (%)		13.84	16.86
17	Year of Release		2022	2022
18	Breeder and Maintainer		SARC(OARI)	SARC(OARI)

Table 2: Mean grain yield(kg/ha) of 14 Linseed genotypes across locations and years

Entry	Sinana			Agarfa			Mean	Yield Adv. over St. check
	2018	2019	2020	2018	2019	2020		
EH010004-7	2120	1373	2298	1408	1429	3061	1948	
EH0100010	2061	2030	2452	2032	1404	2005	1997	
EH01000-3	1822	1547	2237	1507	1535	1569	1703	
ACC230660	1992	2079	3137	2046	2079	2351	2281	
ACC233994	1863	2046	2717	1717	1748	1687	1963	
EH010004-5	1910	1598	2265	1841	1875	1455	1824	

ACC 242594	1939	2229	2812	1611	1646	2899	2189	
ACC234005	2067	1252	2320	1720	1749	1105	1702	
ACC 230826 Filera	**2585**	**2019**	**2675**	**2570**	**2319**	**2715**	**2480**	16.86%
EH010007-7: Keyeron	**2634**	**2135**	**2142**	**2245**	**2198**	**3145**	**2417**	13.84%
EH010001-4	1557	1505	2769	1589	1688	2102	1868	
ACC 230822	2134	1343	2907	2314	2347	1633	2113	
Jitu	2075	1943	2299	2181	1817	2162	2123	
Dibane	1318	1417	1494	1508	1672	1687	1516	
Local	1246	1212	1006	1045	1056	1123	1115	
MEANS	1955	1715	2369	1823	1771	2047	1949	
5% LSD	347.5	624.0	978.8	823.2	821.1	904.4	343.9	
C.V.	12.0	21.7	24.1	21.6	23.1	21.5	21.2	

Table 3: Mean Seed yield and other agronomic traits for 14 linseed genotypes tested in Regional Variety Trial combined over two locations (Sinana and Agarfa) over three years (2018-2020)

Entry	Days to Flower	Days to Mature	Stand %	Plant ht. (cm)	Diseases (0-5 scale)			TSW (g)	SY (Kg/ha)
					Pasmo	PM	Wilt		
EH010004-7	66	145	81	93	5	5	5	5.7	1948
EH0100010	67	145	81	92	4	5	5	5.7	1997
EH01000-3	64	141	69	87	5	5	5	5.3	1703
ACC230660	68	144	76	89	5	5	5	5.1	2281
ACC233994	64	142	70	82	5	5	5	5.1	1963
EH010004-5	65	141	70	83	5	5	5	5.3	1824
ACC 242594	67	144	70	89	5	5	5	5.4	2189
ACC234005	67	141	68	84	5	5	5	5.1	1702
ACC 230826 (Filera)	**69**	**145**	**82**	**93**	3	2	3	**5.1**	**2480**
EH010007-7(Keyeron)	**67**	**146**	**81**	**90**	3	3	3	**5.9**	**2417**
EH010001-4	60	142	77	85	5	5	5	5.3	1868
ACC 230822	66	144	79	90	5	5	5	5.2	2113
Jitu	68	146	83	94	5	4	4	5.9	2123
Dibane	68	145	82	96	5	5	5	5.9	1516
Local	67	144	81	94	5	4	5	5.6	1115
Mean	66	144	77	89				5	1949
5%LSD	1.2	5.7	6.2	8.8				0.2	343.9
CV%	3.3	7	14.2	17.4				6.8	21.2

Note: *DF = days to 50% maturity, DM, days to 90% maturity, PH = plant height (cm), TSW= Thousand seed weight (g), SY = Seed yield (kg), PM =Powdery mildew.*

Table 4: Mean seed yield, agronomic traits and disease reaction of 'Filera and Keyeron' along with standard and local checks tested in two environments at varietal verification levels during the 2018-2020 cropping seasons

Entry	Agronomic traits						Oil Content%	Disease Reaction (1-9)		
	DF	DM	Stand %	PH (cm)	TSW (g)	SY (kg/ha)		Pasmo	PM	Wilt
ACC 230826 (Filera)	69	145	82	93	5.1	2480	42.84	3	2	3
EH010007-7(Keyeron)	67	146	81	90	5.9	2417	43.67	3	3	3
Jitu	68	146	83	94	5.9	2123		5	4	4
Dibane	68	145	82	96	5.9	1516		5	5	5
Local	67	144	81	94	5.0	1115		5	4	5

Note: *DF = days to 50% maturity, DM, days to 90% maturity, PH = plant height (cm), TSW= Thousand seed weight (g), SY = Seed yield (kg), PM =Powdery mildew.*

7. VARIETY MAINTENANCE

The breeder and foundation seed will be maintained by Sinana Agricultural Research Center/ Oromia Agricultural Research Institute.

8. CONCLUSIONS

Filera and Keyeron Linseed varieties were released based on their higher grain yield (Filera), ideal grain color (high oil content) particularly Keyeron (Light yellow), Such varieties fetch higher market prices as compared to other varieties due to the preferred light-yellow seed color and hence could improve the income of smallholder farmers cultivating the crop in the study areas and their vicinities. In addition, these two varieties were found to be tolerant to major diseases of linseed that prevailed in the growing areas such as, Powdery Mildew, wilt and pasmo disease. The linseed varieties Filera and Keyeron are well adapted to the highlands of Bale and other similar agroecological zones in Ethiopia. Their cultivation has the potential to enhance linseed production and productivity, thereby contributing to the alleviation of the country's chronic edible oil shortage while increasing the availability of raw material for domestic consumption and export markets.

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Author contributions

All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Amanuel Tekalign. The first draft was written by Amanuel Tekalign, and all authors commented on previous versions. All authors read and approved the final manuscript.

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Data availability

Data will be made available on request.

Declarations

Ethics approval and consent to participate

The experiments conducted in this study comply with the current laws and regulations of Ethiopia regarding agricultural research. No ethical approval was required, as the study did not involve human participants, vertebrate animals, or biological materials requiring such oversight. All field trials were performed in accordance with environmental safety standards to minimize ecological impact. This study did not involve human participants. Therefore, no consent to participate was required or obtained.

Consent for publication

All authors have reviewed and approved the final version of the manuscript and consent to its submission and potential publication in Environmental Science and Pollution Research. We confirm that the work is original, has not been published elsewhere, and is not under consideration by any other journal.

Competing interests

The authors declare no competing interests.

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