

Performance of Recently Released Linseed (*Linum usitatissimum* L.) Variety (Kuma) in South Eastern Highlands of Ethiopia

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Abstract: Linseed (*Linum usitatissimum* L.) is one of the most important oil crops in the highlands of Ethiopia and it is considered as the least expensive source for oil related home consumptions. Linseed is an important, yet under-utilized oilseed crop of the world. It can be used as food and feed, as raw material for pharmaceuticals, industrial use, textile industries etc. It is an excellent source of omega 3 fatty acid and can be used as a substitute for non-fish eaters. Kuma (R734D x B-96/111) is a common name for the linseed variety developed through a local cross between released variety (Belay-96) and a variety developed through mutation breeding obtained from Holetta Agricultural Research Center/HARC and released in 2015 for highland areas of Arsi and West Arsi zones and other similar agro-ecologies of Ethiopia. Kuma was selected, developed and released by Kulumsa Agricultural Research Center for Arsi and West Arsi Zones and similar agro-ecologies of linseed growing areas of Ethiopia. Specifically, it was tested at Kulumsa, Bekoji, Asasa and Kofele for two years (2012/13 – 2013/14). The two consecutive years' (2012/13 – 2013/14) tests proved its superiority in grain yield performance, stability and wide adaptation. It has good physical grain quality, resistance to powdery mildew and wilt, moderate resistance to pasmo, lodging tolerance and good biomass yield. The results of the multi-location trials revealed that Yadanno was superior in seed and oil yields performance across years and locations. The variety's agronomic and quality merits and better performance than the checks make it dependable for similar agro-ecologies considered in the study.

Keywords: Kuma, Linseed, Variety, Mutation

1. Introduction

Linseed (*Linum usitatissimum* L.; 2n=30) is an important oilseed and fiber crop which belongs to the family Linaceae. It is believed that this crop species may have originated from *Linum angustifolium* Huds. It is one of the widely grown and economically important oil crops for industrial use. Linseed is an annual field crop that is largely grown in temperate climates [9] and cool tropics including the highlands (>2500 m above sea level) of Ethiopia. Linseed is one of the most important oil crops in the highlands of Ethiopia. It is cultivated for seed production, which is used for extracting edible oil. Ethiopia is considered the secondary center of diversity and the 7th major producer of linseed in the world after Canada, China, Russian, India, Kazakhstan and United

States [4]. Linseed has long history of cultivation by smallholder farmers, exclusively for its oil in the traditional agriculture of Ethiopia [6]. It is a major oilseed and the second most important oil crop after noug (*Guizotia abyssinica* Cass.) in Ethiopia. Although linseed plants have several utilities, it is cultivated commercially for its seed, which is processed into oil and after extraction of oil, a high protein stock feed is left [12, 8]. Fibers obtained from the stem are known for their length and strength and are two to three times as strong as those of cotton [13].

Linseed oil is suitable for human consumption, and is used as a nutritional supplement. It is rich in omega-3 fatty acids, especially alpha-linolenic acid (C18:3) that is beneficial for heart disease, inflammatory bowel disease, arthritis and a variety of other health conditions. The seed composition

varies with variety, size, climate and maturity. The seed contains oil (36-48%), which is high in unsaturated fatty acid especially linolenic acid [7, 11] and about 6% mucilage, which resides in the seed coat. The seed has all essential components like crude fibre (5-10%), proteins (20.3%), fats (37.1%), minerals (2.4%), carbohydrates (28.9%), moisture (6.5%), calcium (170 mg/100 g), iron (370 mg/100g), carotene (2.7mg/100 g), thiamine (0.23 mg/100g), riboflavin (0.07 mg/100g), niacin (1.0mg/100g) together with wax, resin, phosphorus, sterols and small quantity of cyanogenic glucoside-linamarin [10]. After the extraction of oil from the linseed seed, the residue left behind is called cake, which is brown in colour. Prior to defatting (to remove all or almost all), this cake contains 21.78% of non-nitrogenous extract, 29.37% lipids and 27.78% protein, 7.02% fibre, 3.40% ash and 10.65% total humidity [5]. Linseed oil cake is one of the best nitrogenous fertilizer among oilcakes with respect to nitrogen, phosphorus and potassium (4.7% N, 11.7% P₂O₅, 1.3% K₂O) contribution to soil [1].

It is a self-pollinated crop it also contains a group of chemicals called lignin that play a significant role in the prevention of cancer [2]. The crop performs best in altitudes ranging from 2200 to 2800 meters above sea level (masl). According to [3], it covered an area of 69,149.87 ha of cultivated land, and produced 796,948.86 quintals with productivity of 11.52 quintal per ha. Earlier time area of linseed was increased from 142,899 hectares (ha) in 2003/04 to 180,873 ha in 2008/09. In the same years, its production and average yield were also increased from 0.77 to 1.56 million quintals and from 541 to 863 kg ha⁻¹, respectively. The realized reductions could be attributed mainly to: inherent low productivity of the crop, market volatility, consistent tax exempted edible oil importation like palm oil, lack of international collaboration on the crop improvement and development efforts, lack of germplasms exchange, limited government budget support, limited extension support, less suitability of the crop for mechanized operations, consistent market price increase for cereal and pulse crops specially for wheat and faba bean, and better availability of mechanized and pesticides technologies and services for competent commodities like bread wheat. It is commonly grown on marginal lands with less or no input [14]. In Ethiopia edible oil sector consists of two groups of producers: the local, small-scale processors (>1000) and a few medium and large scale enterprises (~20), while domestic demand is estimated at 200,000 tons. The increase of import suggests a potentially large domestic market. Main edible oil imports are palm and soybean oils from Malaysia and Indonesia. Substitution of these oils by domestic production is encouraged by high domestic prices. It can be seen as a business opportunity to increase the local capacity to produce linseed and sesame oils for export, increasing added value, foreign exchange and employment opportunity. Increasing seed yield of linseed is the main breeding objective along with others such as breeding for quality, disease resistance, frost resistance etc. This paper presents

the overall performances of the recently developed and released linseed variety (Kuma) with the aim to play a significant role in solving the chronic edible oil shortage in the country, and to exploit its linseed production capacity for domestic uses and export purposes.

2. Methodology

Kuma (R734D x B-96/111) was a local cross between released variety (Belay-96) and a variety developed through mutation breeding obtained from Holetta Agricultural Research Center/HARC. After crossing, F generations (F₂ to F₅) of linseed crosses had been screened on artificially developed wilt (*Fusarium oxysporum* f. sp. lini) sick plots in order to select and advance lines with good agronomic performances and diseases resistance. Kuma outshined several linseed selections, accessions and lines in observation and preliminary yield trials, it was advanced to regional variety trial to be tested across wide locations over years to further test its overall performances. The linseed regional variety trial consisting 16 linseed genotypes including the standard check (Bekelecha) and the local check was conducted at major linseed growing districts of Arsi and West Arsi Zones including Kulumsa, Bekoji, Asasa and Kofele for two growing seasons (2012/2013 to 2013/2014). In these locations, the altitude ranges from 2200 masl (Kulumsa) to 2780 masl (Bekoji), and average annual rainfall ranges from 620 mm in Asasa to 1100 mm in Bekoji.

The genotypes were tested across four locations in RCB design with four replications. Plot size was six rows of 20 cm apart and 5 m long. A seed rate of 25 kg ha⁻¹ and fertilizer rate of 23/23 kg ha⁻¹ N/P₂O₅ was applied at planting at each location, except at Kulumsa where fertilizer was not applied to minimize lodging. Other recommended agronomic practices were also applied. Necessary agronomic performances and disease reactions were recorded.

2.1. Agronomic and Morphological Characteristics

The agronomic and morphological characteristics of Kuma are given in Table A1.

2.2. Grain Yield Performance

In order to develop improved linseed variety, higher seed yield, oil content and resistance to major linseed diseases were important traits of consideration. In this regard Kuma significantly higher grain yield of 1750 -2100 kg/ha was recorded across research stations; and a higher average grain yield in farmers' field ranged from 1450 -1850 kg/ha. These grain yield ranges obtained from a variety Kuma was significantly higher than respective ranges of average grain yield recorded for check varieties across locations. Kuma consistently high yielder than other tested linseed entries over two years. Combined years over locations analysis revealed that it had produced an average yield of 2,227 kg ha⁻¹ (Table 1).

Table 1. Seed yield and agronomic performance of linseed genotypes tested under Regional Variety Trial-Set III at Kulumsa, Bekoji, Asasa and Kofele combined over two years' period (2012/13 and 2013/14).

Plot	Treatments	DF	DM	PM	Pasmo	Wilt	PH	Lodg%	Stand%	TSW	AYKH
1	R734D x B-96/88	85	158	0.5	1.1	0.8	102	30	81	5.9	1978
2	R12N10D x Berene/21	75	155	0.5	1.5	0.3	90	23	83	6.0	1836
3	R12N10D x CI-1525/11	80	155	0.5	1.7	1.0	101	19	83	5.8	1750
4	R734D x B-96/18	82	159	0.4	1.3	0.6	91	34	81	6.3	1787
5	R734D x B-96/147	87	159	0.9	1.2	0.5	100	23	82	5.3	1999
6	R734D x B-96/45	86	155	0.4	1.3	0.8	100	42	82	5.5	1850
7	R12N10D x CI-1525/9	87	161	0.6	1.1	0.7	102	37	80	5.9	1857
8	R12N10D x CI-1525/3	86	160	0.8	1.2	0.5	98	20	80	6.4	1944
9	R734D x B-96/111	88	160	0.6	1.1	0.4	102	16	83	5.9	2227
10	R734D x B-96/21	82	158	0.4	1.0	0.7	102	28	82	6.2	2080
11	R734D x B-96/94	86	156	0.4	1.6	0.6	99	73	85	5.5	1356
12	R734D x B-96/60	84	157	0.4	1.4	0.6	101	52	81	6.0	1722
13	R12N10D x CI-1525/2	89	160	0.7	1.1	0.4	103	33	81	5.9	1745
14	R734D x B-96/3	83	157	0.5	1.2	0.7	99	47	83	5.6	1835
15	Bakalcha	85	160	0.7	1.3	0.5	99	47	82	5.5	1691
16	Local check	88	159	1.0	1.9	0.7	93	40	85	4.9	1536
	Mean	85	158	0.6	1.3	0.6	99	35	82	5.8	1825
	LSD (0.05)	1.3	1.5	0.24	0.23	0.21	3.0	13.3	3.5	0.21	207.6
	CV (%)	2.1	1.9	32.9	27.6	56.0	4.7	57.0	7.1	0.8	14.4

Where, DF=days to flowering, DM=days to maturity, PM=powdery mildew (0-5 scale), PH=plant height in cm, Lodg% =Lodging percent, TSW=1000-seed weight in gram, AYKH=adjusted seed yield in kg/ha.

The results of the multi-location trials revealed that Kuma was superior in seed yield and diseases resistance across years and locations.

2.3. Reaction to the Major Diseases and Quality Traits

The mean reactions of the varieties to the major foliar

diseases of linseed are as shown in Table 2. The resistance level of the new variety was better than the standard and the local checks for powdery mildew, pasmo and wilt. The physical grain quality of kuma is superior to the checks since its grains are brown colored and heavier in thousand grain weight unlike the light seeded local check (Table 2).

Table 2. Mean agronomic, disease reaction and oil content data of Kuma and the checks across locations and years.

Plot	Treatments	DF	DM	PM	Pasmo	Wilt	PH	Lodg%	OC
1	R734D x B-96/111	88	160	0.6	1.1	0.4	102	16	39.3
2	Bakalcha	85	160	0.7	1.3	0.5	99	47	38.8
3	Local check	88	159	1.0	1.9	0.7	93	40	36.8
	Mean	87	160	0.8	1.4	0.5	98	34	38.3
	LSD (0.05)	1.3	1.5	0.24	0.23	0.21	3.0	13.3	12.7
	CV (%)	2.1	1.9	32.9	27.6	56.0	4.7	57.0	37.4

Where, DF=days to flowering, DM=days to maturity, PM=powdery mildew (0-5 scale), PH=plant height in cm, Lodg% =Lodging percent, OC =Oil Content in percent.

Linseed requires moderate to cool temperatures and adequate moisture during the growing season for optimum seed yield and quality. Good yield can be achieved with a temperature range of 10-30°C, and a mid-day relative humidity of 60-70%, and a rainfall of 150-200 mm distributed over the growing periods. Typically, linseed consists of approximately 40% fat, 28% dietary fiber, 21% protein, 4% ash and 6% carbohydrates such as sugars, phenolic acids, lignans, and hemi-cellulose [15]. Linseed is rich in polyunsaturated fatty acids, particularly alpha-linolenic acid (ALA), the essential omega-3 fatty acid, and linoleic acid (LA), the essential omega-6 fatty acid. These two polyunsaturated fatty acids are essential for humans-that is, they must be obtained from the fats and oils in foods because

our bodies cannot make them. In the present study, the results of laboratory tests (Table 2) indicated that kuma contained 39.3% oil content and it had 878.2 kg/ha oil yield.

3. Conclusions

Kuma (R734D x B-96/111) was superior in grain yield performance in most environments with satisfactory grain yield stability. It is more resistant to powdery mildew and wilt than the checks and comparable for pasmo. It has better agronomic characteristics, particularly lodging tolerance with good grain yields. The superiority of its physical grain quality compared to the standard and the local check was also among its important merits. Kuma produced higher seed and oil

yields and contained better oil content. Farmers also preferred the variety for its overall superior performance over the existing local variety. Therefore, Kuma was verified and officially released for large scale production in Arsi, West Arsi Zones and similar agro-ecologies of Ethiopia.

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Appendix

Table A1. Agronomic performance of linseed genotypes tested under Regional Variety Trial-Set III at Kulumsa, Bekoji, Asasa and Kofele combined over two years' period (2012/13 and 2013/14).

Plot	Treatments	DF	DM	PM	Pasmo	Wilt	PH	Lodg%	Stand%	TSW
1	R734D x B-96/88	85	158	0.5	1.1	0.8	102	30	81	5.9
2	R12N10D x Berene/21	75	155	0.5	1.5	0.3	90	23	83	6.0
3	R12N10D x CI-1525/11	80	155	0.5	1.7	1.0	101	19	83	5.8
4	R734D x B-96/18	82	159	0.4	1.3	0.6	91	34	81	6.3
5	R734D x B-96/147	87	159	0.9	1.2	0.5	100	23	82	5.3
6	R734D x B-96/45	86	155	0.4	1.3	0.8	100	42	82	5.5
7	R12N10D x CI-1525/9	87	161	0.6	1.1	0.7	102	37	80	5.9
8	R12N10D x CI-1525/3	86	160	0.8	1.2	0.5	98	20	80	6.4
9	R734D x B-96/111	88	160	0.6	1.1	0.4	102	16	83	5.9
10	R734D x B-96/21	82	158	0.4	1.0	0.7	102	28	82	6.2
11	R734D x B-96/94	86	156	0.4	1.6	0.6	99	73	85	5.5
12	R734D x B-96/60	84	157	0.4	1.4	0.6	101	52	81	6.0
13	R12N10D x CI-1525/2	89	160	0.7	1.1	0.4	103	33	81	5.9
14	R734D x B-96/3	83	157	0.5	1.2	0.7	99	47	83	5.6
15	Bakalcha	85	160	0.7	1.3	0.5	99	47	82	5.5
16	Local check	88	159	1.0	1.9	0.7	93	40	85	4.9
	Mean	85	158	0.6	1.3	0.6	99	35	82	5.8
	LSD (0.05)	1.3	1.5	0.24	0.23	0.21	3.0	13.3	3.5	0.21
	CV (%)	2.1	1.9	32.9	27.6	56.0	4.7	57.0	7.1	0.8

Where, DF=days to flowering, DM=days to maturity, PM=powdery mildew (0-5 scale), PH=plant height in cm, Lodg% =Lodging percent, TSW=1000-seed weight in gram, AYKH=adjusted seed yield in kg/ha.

Table A2. Oil content (%) data of linseed genotypes tested under Regional Variety Trial-Set III at Kulumsa, Bekoji, Asasa and Kofele in 2013/14.

Plot	Treatments	Kulumsa	Bekoji	Asasa	Kofele	Mean
1	R734D x B-96/88	39	41	41	39	40.0
2	R12N10D x Berene/21	35	40	40	37	38.0
3	R12N10D x CI-1525/11	35	40	39	39	38.3
4	R734D x B-96/18	37	40	40	40	39.3
5	R734D x B-96/147	37	40	37	40	38.5
6	R734D x B-96/45	35	42	41	40	39.5
7	R12N10D x CI-1525/9	36	40	40	38	38.5
8	R12N10D x CI-1525/3	35	37	39	36	36.8
9	R734D x B-96/111	37	40	41	39	39.3
10	R734D x B-96/21	36	39	40	39	38.5
11	R734D x B-96/94	37	40	40	36	38.3
12	R734D x B-96/60	38	41	41	39	39.8
13	R12N10D x CI-1525/2	36	39	40	38	38.3
14	R734D x B-96/3	34	40	37	37	37.0
15	Bakalcha	37	40	40	38	38.8
16	Local check	37	38	36	36	36.8
	Mean	36.3	39.8	39.5	38.2	38.5

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