Journal of
Innovative Agriculture

Research Article
DOI: https://doi.org/10.37446/jinagri/rsa/10.2.2023.9-15

Evaluation of linseed (flax seed) varieties

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Received: 26 December 2022
Accepted: 13 April 2023
Published: 30 June 2023

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Volume: 10
Issue: 2
Pages: 9-15

Linseed is one of the oilseed crops introduced earlier in Ethiopia and is currently grown widely next to sesame and noug. The demand for linseed oil production and home consumption increased and needs production enhancement by providing the ideal varieties for the growers. The objective of the current study was to evaluate the performance of newly released linseed varieties in the agroecology of the West Shewa zone of the Oromia region and identify the highest yielders and a stable variety for the farmers of the area. A total of six improved varieties, including local check, were evaluated using a randomized complete block design with three replications at three districts of the West Shewa zone during the 2020/2021 cropping season. The analysis of variance over multi-locations revealed that varieties across locations were significantly ($p \leq 0.01$) different for phenological traits like days to flower and maturity. Likewise, locations induced a significant variation for all traits evaluated. From the mean performance varieties, Yadeno and Kulumsa-1 gave the highest seed yield of 1641.4Kgha^{-1} and 1516.7Kgha^{-1}, respectively. Besides, variety Yadeno showed a consistence performance across all locations. Thus these two high-yielder varieties have to be demonstrated and promoted to the farmers of the West Shewa zone to enhance the production of linseed.

Key words: *Ethiopia, flax seed, linseed, Linum usitatissimum, multi-location trail, RBD, trait evaluation, performance, yield*

INTRODUCTION

Linseed, *Linum usitatissimum* L. (2n = 30), also called flax, is one of the oilseed crops belonging to the family Linaceae having 14 genera and over 200 species (Seegeler, 1983;

Jhala et al., 2008). Although its origin is not well known, some evidence revealed that a possible origin center of linseed was the Mediterranean area. Linseed was introduced to Ethiopia very early (Belayneh & Alemayehu, 1988, Mhiret & Heslop-Harrison, 2018). Linseed is characterized as long-stemmed and short-stemmed based on its growth habits (Freeman, 1995). Long stemmed linseed produces a high fiber quality but relatively low oil content. The short-stemmed produces high oil, large seed, and has good branching. It also produces many spherical fruits known as bolls which contain compartments, and each may contain about ten kernels (Freeman, 1995).

It is mainly grown for fiber and oil production. Linseed is used for home consumption by preparing a meal and juice from the roasted and ground seed. It is rich in macro and micro minerals helpful in combating malnutrition (Hussain, et al., 2008; Deme et al., 2017; Naik et al., 2020). The investigation on linseed mineral composition indicated that linseed contains 822.1mg K, 236.4mg Ca, 422.5mg Mg, 30.12mg Na, 6.01mg Fe, 4.43mg Zn, 2.73mg Mn, and 1.9mg Cu in 100g of seed. It also contains carbohydrates, proteins, lignans, tannin, omega-3 fatty acids, phaytic acid, and phosphorus. Linseed is a source of linolenic acid (50-60%) that is very good for human health and especially beneficial for the growth of the infant's brain (Soni et al., 2016). It also helps to reduce and relieve the risk of diabetes, blood glucose, cardiovascular diseases, atherosclerosis, colorectal cancer, inflammation, osteoporosis, autoimmune and neurological disorders (Goyal et al., 2014; Soni et al., 2016; Naik et al., 2020). The consumption of linseed helps reduce obesity and cholesterol to a great extent (Naik et al., 2020). Its seed is used for pharmaceuticals porpuse to produce expectorant, emollient, diuretic and demulcent (Goyal et al., 2014). Linseed is also consumed in the paint and varnish industry to manufacture different printing inks, soaps, linoleum, greases, lubricants, and polishes (Jhala et al., 2010). In addition to industrial application, its bi-product and biomass are highly useful for feeding livestock.

The production of linseed was 2.9 million tons all over the world. Out of this, Canada (38%) has the largest share, followed by the USA (17%), China (17%), and Ethiopia (4%) (Wijnads et al., 2007). In Ethiopia the major Linseed growing areas are found in the altitudes ranging from 1800 to 2800m, although it is grown at altitude as low as 1680m or as high as 3430m (Adefris et al., 1992). Recently, linseed covered 79,044.51 hectares of cultivated land and has a production of about 882,09.651 ton. From this, 3,637.81 hectares covered by linseed and 58,07.154 ton produced from only West Shewa zone. Its productivity is 1.094tha^{-1} and 1.596tha^{-1} as a national and West Shewa zone, respectively (CSA, 2017). This indicates in the West Shewa zone linseed production potential is better. In addition, the intervention of appropriate improved varieties is crucial in order to increase the production. Some attempts have been done to improve the limitation of ideal linseed varieties for the area of West Shewa zone by Holeta Agriculture Research Center (HARC). However, that is not enough and satisfying the farmers demand regarding the option and accessibility of improved varieties. Hence, this study was conceived to evaluate the newly released linseed varieties to the agro-ecology of the West Shewa zones of Oromia region, Ethiopia and identify the most high yielders and stable varieties for the farmers.

MATERIALS AND METHODS

Description of the testing site

The experiment was conducted at three districts of West Shoa zone in Oromia region; Liben Jawi, Dire-Inchini and Ambo districts. At Liben Jawi the trial was repeated during 2020 and 2021 cropping season and its mean was used for analysis whereas, for the remaining locations the trial was not repeated. Liben Jawi district lies between 8°9′80″N latitude and

37°71′E longitude with an altitude range of 1500-3051 meter above sea level (Balemi et al., 2015; Abera et al., 2018). It is receiving an average annual rainfall of 1040mm with uni-modal distribution (Abera et al., 2018). It has a medium cool sub-humid climate with the mean minimum, mean maximum, and average air temperatures of 8.9, 27.4, and 18.1°C, respectively (Abera et al., 2018). Its soil type is brown clay loam ultisols (Abera et al., 2018). Ambo district is situated at 8°56'30" - 8°59'30" N latitude and 37° 47'30" - 37°55'15" E longitude with the altitude of the area ranging from 1380-3030m.a.s.l, and 2510m.a.s.l, particularly for the Altufa village where the trial was conducted, which is characterized by a cool highland weather condition. The district is featured with 15°C-29°C temperature ranges with 22°C mean temperature and receives 800-1000mm a mean annual rainfall. The mean monthly relative humidity varies from 65% in August to 36% in December, and the maximum rain occurs from June to September (Willy, 2018).

Dire-Inchini is located at 8°56'30" - 8°59'30" N latitude and 37° 47'30" - 37°55'15" E longitude with 165Km distance from the capital city to the west and 50Km from Ambo town (Zewudu & Tussie, 2019). It is characterized by an altitude range of 2200-3023, annual average rainfall of 1000-1800mm, annual average temperature of 6-24°C and soil pH of 5.0-6.1 (Balemi et al., 2015).

Plant materials

The experimental material consists of five improved varieties (Kulumsa-1, Welen, Yadeno, Kuma and Bekoji-14) and a local check from where the trial was conducted (Table 1). All materials except local check were kindly obtained from Holeta Agricultural Research Center (HARC).

Table 1. Details of linseed varieties used in the field experiment

S.No.	Varieties	Pedigree	Released by	Year of release	Seed color
1	Kulumsa-1	Chilallo/16	KARC	2006	Brown
2	Welen	PGRC/E 16033xCI-1652/36	KARC	2019	Brown
3	Yadeno	H31 X Belay-96-208	KARC	2015	Brown
4	Kuma	R734D X B-96/111	KARC	2016	Brown
5	Bekoji-14	-	HARC	2014	Brown
6	Local check	NA	NA	NA	Brown

NA: Not available, KARC: Kulumsa Agriculture Research Centre, HARC: Holeta Agriculture Research Centre.

Experimental design and management

The experiment was conducted by a randomized complete block design (RCBD) with three replications. Each plot consists of six rows of 2m in length with 0.2m inter-row space. The plot's and block's distances were 0.8m and 1.5m, respectively. A seed rate of 30kgha^{-1} drilled by hand within the prepared rows. A recommended fertilizer rate of 23kgha^{-1} of P_2O_5 in the form of NPS and 23kgha^{-1} of N in the form of Urea were applied.

Data collection and statistical analysis

Collected data are based on plot and individual plant. The plot based data are biomass, seed yield, flowering maturity date, grain filling period, lodging, and stand percent. Whereas the plant based data are plant height, primary branch, and pod number. For the data collected from individual, an average of five individual plants were used, and all collected data were subjected to statistical analysis based on the procedure of RCBD (Gomez & Gomez, 1984). R-package Version 4.1.6. was used for statistical analysis.

RESULTS AND DISCUSSION

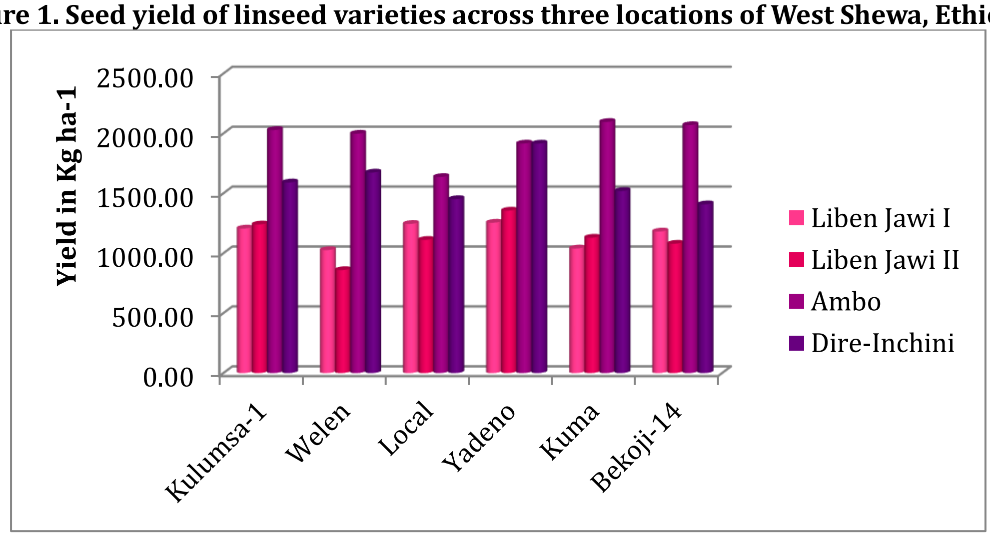
The analysis of variance of combined data over location for all traits is presented in Table 2 (Figure 1). The high significance (p ≤ 0.01) difference among varieties was observed for days to heading, maturity, grain filling period and plant height. The interaction of varieties verses locations was highly significant (p ≤ 0.01) for only phonological traits like days to flowering and maturity. The variation in weather conditions and soil fertility always has an impact on agronomic traits (Merga et al., 2019). The locations were induced a significant variation for all traits which is due to the differences in soil type and weather conditions. Statistically, the varieties across location interaction didn't show a significant variation in grain yield, which indicates the consistency of cultivars across locations (Sileshi et al., 2019). Previous studies reported that there was no significant difference in variety with location interaction for grain yield (Wossen et al., 2016).

Table 2. Mean performance of linseed varieties over locations

No	Variety	SY	ABM	DtF	DtM	GFP	StP	PH	PB	NPP	% yield advantage
1	Kulumsa-1	1516.66	6398.60	84.17	141.00	57.17	88.00	93.96	5.00	30.14	11.42
2	Welen	1389.46	5530.22	79.50	140.75	60.92	80.75	87.25	5.42	29.47	2.07
3	Local	1361.23	5413.89	82.50	138.92	55.08	84.58	84.09	6.17	26.15	-
4	Yadeno	1610.41	5822.92	78.58	142.50	63.50	84.00	83.03	5.64	28.41	18.31
5	Kuma	1446.24	6292.35	81.50	142.50	61.17	85.92	88.83	5.58	28.31	6.25
6	Bekoji-14	1434.73	5357.63	85.42	142.33	56.42	86.75	90.13	5.47	27.87	5.40
CV%		16.66	27.14	1.52	1.36	4.70	7.92	6.88	15.23	18.15	
Variety		ns	ns	**	**	**	ns	**	ns	ns	
Location		**	**	**	**	**	**	**	**	**	
Variety*Location		ns	ns	**	**	ns	ns	ns	ns	*	

**: highly significant, ns: not significant, SY: seed yield, ABM: above ground biomass, DtF: days to flower, DtM: days to maturity, GFP: grain filling period, StP: stand percent, PH: plant height, PB: primary branches, NPP: number of pod per plant.

Figure 1. Seed yield of linseed varieties across three locations of West Shewa, Ethiopia.



From the mean performance of combined analysis, the highest seed yield obtained from the variety Yadeno (1641.4Kgha^{-1}), followed by Kulumsa-1 (1516.66Kgha^{-1}), and Kuma (1446.24Kgha^{-1}), whereas the lowest seed yield was from local check (1361.23Kgha^{-1}).

Variety Yadeno and kulumsa-1 have about 18% and 11% yield advantage over the local check, respectively. This variety was also relatively stable across the tested locations. Similarly, another study conducted at the West Arsi zone of Oromiya supported that the cultivar Yadeno has a superior seed yield and 114% of yield advantage over the check (Abebe et al., 2022).

Figure 2. Performance of linseed cultivars at Ambo (A), Dire-Inchini (B) and Liben Jawi (C).

A B C

The maximum plant height was recorded for the variety kulumsa-1 (94cm) followed by Bokoji-14 (90cm) and Kuma (89cm), whereas the low plant height was for Yadeno (83cm) (Table 2). The varieties which have relatively shorter plant height may be more tolerant to lodging. Location influenced the performance of cultivars because the sites are not similar in weather conditions and soil fertility (Figure 2). The highest grain yield performance was observed at Ambo and Dire-Inchini locations, whereas at the Liben Jawi districts, the performance of varieties was low. These two locations (Ambo and Dire-Inchini) are relatively suitable agroecology for the production of linseed as compared to the Liben Jawi district.

CONCLUSION

According to the combined analysis over three locations; the variability in weather condition and soil fertility of the locations significantly influenced the seed yield and other traits of linseed. Based on the result of combined data, variety Yadeno and Kulumsa-1 gave the highest mean seed yield respectively among all the tested varieties. Likewise the variety Yadeno was consistently better than local check and relatively stable across all locations. Therefore, in the future it is important to demonstrate and promote these two varieties to the farmer in the west Shewa zone of Oromia region through extension and demonstrations program.

ACKNOWLEDGMENTS

The authors would like to express their thanks to the highland oil program coordinating center (Holeta Agriculture Research Centre) for providing budget and varieties, and Ambo Agricultural Research Center for facilitating the necessary requirements during the trial implementation.

AUTHOR CONTRIBUTIONS

M.M. designed and implemented the experiment and wrote up the manuscript, W.M. and K.M. implemented the experiment.

COMPETING INTERESTS

The authors declare they have no conflict of interest. The manuscript has not been submitted for publication in other journal.

ETHICS APPROVAL

Not applicable

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