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Registration of "Welen", a Newly Released Linseed Variety for Highlands of Ethiopia

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Abstract: Welen (PGRC/E 16033xCI-1652/36), is a common name for the linseed variety developed through hybridization and continuous selections using pedigree method. The national Oil Crops research program objectively works on the development and release of resistance Oil Crops variety for Linseed disease with high grain yield and good quality. Welen produced better seed yield kg/ha than the standard check Furtu. It had medium height brown seed variety, days to heading and days to maturing period of linseed was selected and developed 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 (2015/16 to 2016/17) and verified in 2017/2018 at 2018/2019 official release. As a result, Welen consistently produced better mean seed and oil yields than the standard check (Furtu) and the local check over two years. The results of the multi-location trials revealed that Welen was superior in seed and oil yields performance across years and locations. Besides, it is stable, best adapted, having large number of capsules per plant, high tillering capacity, thousand seed weight, and oil content, moderately resistant to powdery mildew (Oidium sp.), pasmo (Septoria linicola) and wilt (Fusarium oxysporum f.sp. lini) diseases.

Keywords: Welen, Variety Registration, Oil Content, Oil Yield

1. Introduction

In Ethiopia Linseed (*Linum usitatissimum* L.) is one of the most important oldest plant species cultivated for seed yield and oil traits. It is the second most important oil crops in the highlands of Ethiopia next to noug in terms of area and production with a productivity of about 1.116 t/ha [1]. Linseed/flax (*Linum usitatissimum* L.) is 2x=2n=30 is an annual self-pollinated crop. Among oil crops linseed/flax is the third important commodity next to sesame (*Sesamum indicum* L.) and noug (*Guizotia abyssinica* Cass.) in Ethiopia. And the first important oil crop in Oromia Regional State and Arsi Zone, respectively [2]. During 2015/16 cropping season, 746,581 subsistence farmers allocated 85,415.67 hectares of land for linseed production and produced 88,551 tons of linseed with an average yield of 1.04 t/ha [3]. Linseed (*Linum usitatisimum* L) It is one of the most important oil crops of Ethiopia and it is considered as the least expensive source of oil for the farmers in many highlands of the country. It is widely grown in areas having an altitude range of 1,800-2,600 meter above sea level with annual rainfall ranging from 750-1,000 mm in Ethiopia. In Ethiopia, it is the fourth important oilseed next to sesame, Neug and groundnut both in terms of acreage and total production [4]. In Ethiopia linseed has long history of cultivation by smallholders' farmers for household consumption manly used for its edible oil in Ethiopia. However, the byproduct of linseed after oil extraction is used for animal feed [5]. Linseed is grows well in either a heavy sandy loam or light clay soils with a good drainage system [6]. The crop is traditionally used for many purposes, such as source of food, feed, fiber, oil, medicine, industrial raw material and export commodity. Linseed cake is rich in microelements, vitamins, dietary cellulose, proteins (up to 38%). Major production constraints of the Ethiopian linseed are low national seed yield productivity, Low oil content, susceptibility to wilt, pasmo and powdery

mildew diseases, susceptible to parasitic weed (dodder) and other weeds (grass and broad leaves), susceptible to frost and acidic soils, sterility due to environmental disorders (micronutrients deficiency, shortage and excess rains, etc), different fatty acid profiles for different purposes/products (e.g., high linolenic, >50% for health and industrial purposes; low, < 2% linolenic for cooking oil, intermediate level for margarine) Crop improvement through successful selection program largely depends on the nature and magnitude of genetic variability present in the germplasm, [7].

The Seeds of Linseed are rich in omega-3 fatty acids (FA) and lignans, are a source of high-quality protein and soluble fiber and also have considerable potential as a source of phenolic compounds [8]. The oil content of linseed seed ranges between 35% and 45% (w/w), although even higher values have been reported [9]. Generally, linseed seed oil contains approximately 9–11% saturated (5–6% palmitic acid and 4–5% stearic acid) and 75–90% unsaturated FA (50–55% α-linolenic acid, 15–20% oleic acid [10]. Compared to other oilseed crops, linseed oil is the richest source of omega-3 and α-linolenic acid (ALA) [11]. Linseed seed oil also has a beneficial ratio (n-6:n-3) of fatty acid (FA) of approximately 0.3:1 [12, 13]. Genetic and environmental factors such as soil and climate can influence linseed seed yield, oil content and the FA composition of seed oil and seed press cake [8, 15, 16]. Linseed variety influences the quality of the seeds, and respective varieties must be chosen to improve the linseed product quality [17]. Hence, concerted research, development, promotion, infrastructure and policy intervention efforts are needed, at all levels, in order to reverse the current situations. This paper presents the overall performances of the recently developed and released linseed variety (Welen) with the aim to play a significant role in solving the chronic edible oil shortage in the country, and to exploit its linseed production and productivity capacity for domestic uses and export purposes.

2. Materials and Methods

The experiment was conducted in experimental field at Kulumsa, Bekoji, Asasa and Kofele Agricultural Research Centres during 2015/2016 and 2016/2017 cropping season. The test locations are the main testing sites for highland linseed varieties. Those are believed to represent the major crop growing agro ecologies of Ethiopia in the central highland areas. The experiment was carried out to assess genetic variability, correlation and path analysis of Linseed genotypes for seed yield, oil content and their component traits of fifteen genotypes of linseed against one standard check (Furtu variety). Plot size was six rows of 20 cm apart and 5m long. A seed rate of 25 kg ha^{-1} and fertilizer rate of 23/23 kg ha^{-1} N/P_2O_5 was applied at planting at each location, except at Kulumsa where fertilizer was not applied to minimize lodging. Other recommended cultural practices were also applied. Necessary agronomic performances and disease reactions were recorded.

Agronomic and Morphological Characteristics

In an attempt to develop Welen, higher seed yield, oil content and resistance to major linseed diseases were important traits of consideration. Welen flowered within 89 days and matured within 146 days after emergence (Table 1). Welen was highly uniform and its average height was 85 cm tall and better resistance to lodging. Welen have brown and bold seeded. The average weight of 1000-seeds was 6g for Welen, which is greater by Better seed yield produced 12.1% and 9.5% Over Furtu and 30% & 27.9% Over Local Check seed yield advantage. (Table 2). Welen is a variety suitable for rain-fed, low inputs and organic farming on different soil types as long as the pH value is within the range of 6.0 to 7.6. However, it is not suitable for water logged or poorly drained soils.

Table 1. *Agronomic and morphological characteristics of Welen linseed variety Adaptation area.*

1. Rainfall (mm):	600-1100
2. Altitude (m):	2000-2800
3. Seed rate (kg/ha):	25 for row planting and 40 for broadcasting
4. Planting date:	Early to late June
5. Fertilizer rate (kg/ha):	
P_2O_5:	23
N:	23
6. Days to flower:	89
7. Days to maturity:	146
8. Plant height (cm):	85
9. 1000 seed weight (g):	6
10. Seed color:	Brown
11. Disease reaction:	Resistant to linseed Wilt, Pasmo and Powdery
12. Mildew diseases	
13. Average seed yield (qt/ha)	
a. Research field:	16.43 – 17.43
b. Farmers field:	13.08-14.81
14. Average oil content (%):	39.3
15. Average oil yield (kg/ha):	674
16. Year of Release:	2018/19
17.4. Breeder/Maintainer:	Kulumsa Agri. Research Center

3. Results and Discussion

3.1. Yield Performance

Considering the overall seed yields, Welen (PGRC/E 16033xCI-1652/36) produced better seed yield (1715 kg/ha) than the standard check Furtu (1507 kg/ha) across locations (Table 2). This variety consistently performed better than the checks over two years. Welen was 12.1% high yielder than the standard check (Furtu) and 30% high yielder than the local check.

3.2. Quality

The variety is characterized by having high percent of oil content which can serve as cash crops for the farming community. It had 13.8% oil yield and 2% oil content advantage over Furtu. Likewise, it had 33.2% oil yield and 2.5% oil content advantage over the local check. It was highly uniform with strong stalk and resistant to lodging and showed noble competence with different weed species.

Table 2. *Seed yield and agronomic performance of linseed genotypes tested under Regional Variety Trial at Kulumsa, Bekoji, Asasa and Kofele combined over two years period 2015/16 and 2016/17).*

Plot	Treatments	DF	DM	PM	Psm	Wilt	PH	Lodg%	TSW	Brd	mos	AYKH
1	PGRC/E 16033xCI-1652/5	73	150	0.8	1.3	0.8	87	6.5	5.4	0.8	6.8	1685.8
2	PGRC/E 16033xCI-1652/7	80	151	0.8	1.2	0.2	85	10.1	6	0.2	6.8	1506.4
3	PGRC/E 16033xCI-1652/9	75	144	0.8	1.4	0.2	83	11.2	6	0.6	6.6	1476
4	PGRC/E 16033xCI-1652/13	74	146	0.9	1.3	0.2	84	10.7	6.3	0.3	6.7	1464
5	PGRC/E 16033xCI-1652/21	80	149	0.5	1.3	0.2	86	11.1	6	0.8	6.6	1525
6	PGRC/E 16033xCI-1652/24	80	149	0.9	1.2	0.2	87	17.4	6.3	0.1	6.7	1506.5
7	PGRC/E 16033xCI-1652/31	77	147	0.8	1.4	0.2	79	16.3	5.4	0.9	6.8	1331
8	PGRC/E 16033xCI-1652/36	89	146	0.4	1.1	0.2	85	4.8	6	0.2	6.7	1715
9	PGRC/E 16033xCI-1652/39	80	151	0.3	1.1	0.2	86	3.4	5.7	0.3	6.8	1664.6
10	R12N22GxB.96/13	74	144	0.7	1.2	0.4	86	24.4	5.2	0.3	6.8	1446
11	Kulumsa-1/4	75	142	0.7	1.3	0.3	88	29.5	5.4	0	6.8	1577
12	Kulumsa-1/57	77	146	0.9	1.1	0.4	84	27.2	5.2	0.2	6.8	1513
13	Bekelcha/166	87	145	0.8	1.3	0.6	85	23.7	5.1	1	7.0	1372
14	Furtu	76	147	0.7	1.1	0.3	88	28.7	6	0.5	6.8	1507
15	Local check	80	148	1.1	1.3	1.0	82	32.9	4.6	0.4	7	1201
	Mean	78.8	147	0.9	1.5	0.4	84.8	17.2	5.6	0.5	6.8	1499
	LSD (0.05)	12.6	2	0.1	0.2	0.1	3	8.3	0	0.98	0.01	1499.3
	CV (%)	32.7	2.8	27.8	25.9	55.1	7.3	98.1	0.3	439.4	0.3	18.8

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, Mos=Moisture, Brd=Bird damage, AYKH=adjusted seed yield in kg/ha.

Table 3. *Summary of pooled mean seed and oil yields, other data and diseases reaction of Welen and the checks across years and locations.*

Plot	Treatments	DF	DM	PM (0-5)	Pasmo (0-5)	Wilt (0-5)	PH (cm)	TSW (g)	OC (%)	OY (kg/ha)
1	Welen	89	146	0.4	1.1	0.2	85	6	39.3	674
2	Furtu	76	147	0.7	1.1	0.3	88	6	38.5	581
3	Local check	80	148	1.1	1.3	1.0	84	4.6		

Where, DF = Days to flower, DM = Days to mature; PM = Powdery mildew, PH = Plant height, TSW = 1000 seeds) weight, SY = Seed yield, OC = Oil content, OY = Oil yield.

Table 4. *Seed yield (kg/ha) of linseed genotypes tested under Regional Variety Trial at Kulumsa, Bekoji, Asasa and Kofele in the year of 2015/16 and 2016/17.*

Plot	Treatments	2015/16	2016/17	Mean
1	PGRC/E 16033xCI-1652/5	1686	1685.7	1685.8
2	PGRC/E 16033xCI-1652/7	1670	1342.7	1506.4
3	PGRC/E 16033xCI-1652/9	1484	1467.8	1476
4	PGRC/E 16033xCI-1652/13	1563	1366	1464
5	PGRC/E 16033xCI-1652/21	1605	1444.4	1525
6	PGRC/E 16033xCI-1652/24	1618	1395	1506.5
7	PGRC/E 16033xCI-1652/31	1437	1226.7	1331
8	PGRC/E 16033xCI-1652/36	1687	1743.1	1715
9	PGRC/E 16033xCI-1652/39	1774	1555	1664.6
10	R12N22GxB.96/13	1590	1302	1446
11	Kulumsa-1/4	1712	1442	1577
12	Kulumsa-1/57	1576	1449.5	1513
13	Bekelcha/166	1428	1315.4	1372
14	Furtu	1572	1441.7	1507
15	Local check	1293	1109.8	1201
	Mean	1579.6	1419.1	1499
	LSD (0.05)	206	179.3	1499.3
	CV (%)	18.7	18.1	18.8

4. Conclusions

Welen was the best yielding linseed variety. It is stable in seed yield performance over locations and years. It was resistant to major diseases of linseed that prevailed in the growing areas. Welen 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, which is manifested by high uniformity, tall plant height, firm stalk, better pods load and number of branches per plant. Likewise, the variety has better industrial, non-industrial and nutritional values. Hence, Welen was verified and officially released for large scale production in Arsi, West Arsi Zones and similar agro-ecologies of Ethiopia.

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