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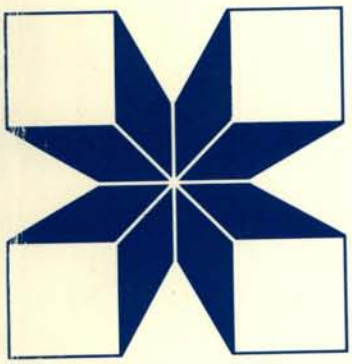

CANADA

OIL CROPS:
PROCEEDINGS OF THE THREE MEETINGS HELD AT PANTNAGAR AND HYDERABAD, INDIA, 4 – 17 JANUARY 1989

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1. The Brassica Subnetwork-II
2. The Other Oil Crops Subnetwork-I
3. The Oil Crops Network Steering Committee-I

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PROGRESS IN LINSEED ON-STATION AND ON-FARM RESEARCH IN ETHIOPIA

Hiruy Belayneh, Nigussie Alemayehu and Getinet Alemaw

Abstract

It is estimated that the total area under linseed exceeds 100,000 ha. However, the national average seed yield is low mainly due to the poor traditional technologies in use. As a result of extensive testing, four high yielding stable improved varieties, namely Victory, Concurrent, CI-1525 and CI-1652 have been released for general cultivation. The latter two are in production currently. The agronomy trials showed that timely planting and weeding are important. The on-farm trial results indicated that linseed yield can be increased substantially by using the improved varieties and management practices. Hence, there is a large room for improving the current average national linseed yield of the country. Weeding of this crop is a profitable proposition. Fusarium wilt and pasmo are recorded as important diseases on linseed. The major insect pests are African bollworm and golden plusia. Chemicals are available to combat these insect pests.

Ethiopia is considered to be the center of diversity for linseed (*Linum usitatissimum* L.) (13). It is the second important oil crop after noug in the country and is grown widely on the highlands for its seed (19). The area under this crop is about 107,270 ha, with an average yield of 357 kg/ha (5). The poor yields under farmers' conditions are partly due to a heavy weed infestation. The main producing areas are in Arsi with adjoining areas in Bale and the Chercher mountains, in eastern Wellega, eastern Gojjam around lake Tana, the Semien mountain, Tigri, Eritrea, south-west Welo and Shoa (19). The crop is commonly cultivated on subsistence level at altitudes between 1800 and 3000m with an annual rainfall above 450 mm (13, 19). It grows on almost all types of soils except dry sands and poorly drained heavy clays. It is often grown on marginal and sub-marginal rainfed soils as pure crop.

A number of options are now available for better returns per unit area. This paper will summarize the promising results available so far.

On-Station Activities

Variety development

The objective of the breeding program is to develop high yielding stable cultivars with resistance to fusarium wilt, pasmo and powdery mildew.

Nearly all linseed varieties grown at present are landraces. Work on the indigenous landraces consisted mainly of making collections, evaluation and maintaining the germplasm. About 470 local collections have been characterized (11). In general, the Ethiopian linseed are short in height and small seeded. On the other hand, as a result of the introduction of exotic materials of diverse origin and extensive testing, four high yielding and stable exotic varieties (Victory, Concurrent, CI-1525 and CI-1652) have been released to producers. The latter two-bold seeded varieties were released in 1984 after fulfilling the pre-release requirements (10). CI-1525 and CI-1652 were improved through mass selection at Holetta from materials originated in France and Ireland, respectively, and have done well nation wide under both fertilized and unfertilized conditions (Tables 1-5).

Table 1. Summary of seed yield in kg/ha of the improved and local varieties in the linseed national and extension trials grown at 16 sites in five Agricultural Development Zone (ADZ) with 23/23 kg/ha of N and P_2O_5 fertilizer (F_1) or without (F_0) 1984-1986 crop season (7,15,17)

Agricultural Development Zone	Site	VARIETIES					
		Improved[1]			Local		
		F_0	F_1	Mean	F_0	F_1	Mean
Central	Sheno	858	967	913	705	871	788
	Holetta	1719	1860	1790	1450	1633	1542
	Debre Zeit	1615	1487	1551	1296	1233	1265
	Goha Tsion	961	1163	1062	813	900	857
	Tefki	852	1192	1022	930	1158	1044
	Shashemene	690	821	756	786	938	862
	Inwarie	536	842	689	492	834	663
	Mean	1033	1190	1112	925	1081	1003
South-eastern	Bekoji	1457	1398	1428	1499	1379	1439
	Kulumsa	1374	1322	1348	1145	1068	1107
	Robe	1234	1131	1183	912	990	951
	Mean	1355	1284	1320	1185	1145	1165
North-western	Dabat	1014	1424	1219	754	1050	902
	Debre Tabor	1652	1896	1774	1252	1592	1422
	Motta	1295	1354	1325	1076	911	994
	Burie	1356	1479	1418	773	1096	934
	Mean	1329	1538	1434	964	1162	1063
Western	Shambu	1463	1884	1674	950	1092	1021
Eastern	Wacho	860	902	881	762	718	740

1 = Average of CI-1525 and CI-1652

Table 2. Seed oil content (%) of the improved and local varieties in the linseed national variety trials grown at five sites in two ADZ with 23/23 kg/ha of N and P_2O_5 fertilizer (F_1) or without (F_0), 1984-1986 crop season (7,15,17)

Agricultural Development Zone	Site	VARIETIES					
		Improved			Local		
		F_0	F_1	Mean	F_0	F_1	Mean
Central	Sheno	37.5	37.6	37.6	34.1	34.5	34.3
	Holetta	36.6	36.9	36.8	32.5	32.5	32.5
	Debre Zeit	34.9	35.2	35.1	32.9	33.5	33.2
	Mean	36.3	36.5	36.5	33.2	33.5	33.3
South-eastern	Bekoji	35.3	35.4	35.4	33.2	32.9	33.1
	Kulumsa	35.4	34.9	35.2	33.2	32.8	33.0
	Mean	35.4	35.2	35.3	33.2	32.9	33.1

Table 3. Weight per 1000 seed (g) of the improved and local varieties in the linseed national variety trials grown at five sites in two ADZ with 23/23 kg/ha of N and P_2O_5 fertilizer (F_1), or with out (F_0) 1984-1986 crop season (7,15,17)

Agricultural Development Zone	Site	VARIETIES					
		Improved			Local		
		F_0	F_1	Mean	F_0	F_1	Mean
Central	Sheno	5.9	6.4	6.2	4.6	3.8	4.2
	Holetta	5.6	5.6	5.6	3.3	3.2	3.3
	Debre Zeit	5.1	4.9	5.0	4.0	3.9	4.0
	Mean	5.5	5.6	5.6	4.0	3.6	3.8
South-eastern	Bekoji	6.4	6.3	6.4	5.9	4.3	5.1
	Kulumsa	5.9	5.6	5.8	4.8	4.5	4.7
	Mean	6.2	6.0	6.1	5.4	4.4	4.9

Table 4. Number of days to maturity of the improved and local varieties in the linseed national and extension variety trials grown at 16 sites in five ADZ with 23/23 kg/ha of N and P_2O_5 (F_1) or without (F_0) 1984-1986 crop season. (7, 15, 17)

Agricultural Development Zone*	VARIETIES					
	Improved			Local		
	F_0	F_1	Mean	F_0	F_1	Mean
Central (7)	139	137	138	135	132	134
South-eastern (3)	155	156	156	141	139	140
North-western (4)	137	136	137	138	137	138
Western (1)	145	142	144	134	131	133
Eastern (1)	127	131	129	110	111	111
Mean (16)	141	140	141	132	130	131

* Number of sites in parenthesis.

Table 5. Plant height (cm) of the improved and local varieties in the linseed national and extension variety trials grown at 16 sites in five ADZ with 23/23 kg/ha of N and P_2O_5 (F_1) or without (F_0), 1984-1986 crop season (7,15,17)

Agricultural Development Zone*	VARIETIES					
	Improved			Local		
	F_0	F_1	Mean	F_0	F_1	Mean
Central (7)	70	75	73	52	60	56
South-eastern (3)	80	83	82	74	73	74
North-western (4)	75	79	77	58	67	63
Western (1)	75	77	76	47	56	52
Eastern (1)	85	90	88	55	67	61
Mean (16)	77	81	79	57	65	61

* Number of sites in parenthesis.

Single plant selections were made in the national and international nurseries to capture within plot variation and uniform lines were produced (8). A number of lines is being advanced through a stage of hierarchy of yield trials.

The major effort in the crossing program has been towards incorporating earliness, wilt resistance and low lodging characters in high yielding linseed cultivars. Work on linseed hybridization at Holetta was

initiated in 1981. Since then, numerous crosses have been made between high yielding parents and lines with the desired characters (8). So far, no superior varieties have been released from the hybridization program. However, promising ones have been advanced to the national variety trial.

Agronomy

A number of agronomic experiments has been undertaken in various research centers on linseed to identify responses of linseed varieties to various levels of management practices. The main results can be highlighted as follows:

It has been realized that seed improvement implies better cleaning of the seed in addition to the cultivation of uniform, high yielding varieties. Cleaning the seed for sowing, combined with one weeding resulted in a 13% higher yield than the uncleaned seed with one weeding (Table 6).

Table 6. Seed yield (kg/ha) of local linseed variety under different purity levels and weeding intensities, Kulumsa 1968 (3).

Purity	Weeding Once	Weeding twice	Mean
Market seed	870	1110	990
Clean seed	980	1150	1065
Mean	925	1130	1028

Seed dressing is often recommended since linseed is fragile and cracked seeds are very susceptible to fungal diseases during germination (19). At Kulumsa, the plant population of linseed was increased by 12% by treating the seed against seed borne diseases. However, it had no effect on seed yield (4).

In Ethiopia, linseed is often planted in poorly prepared seed beds which result in low seed yields. The seed bed should be firm with small lumps, and must be free of weeds.

Since linseed is often grown in agriculturally marginal areas, relationships between rainfall, time of sowing and weeding frequency are very important in achieving an optimum yield (12). Based on date of sowing trials, mid June to early July has been recommended as an optimum time depending on the soil type (Table 7).

Small holders' linseed landraces are invariably broadcast at a rate varying from 4 to 75 kg/ha (19,21). On-station seed-rate experiments showed that relatively small yield difference to wide range of seeding rates. Seeding rate of 25-35 kg/ha for drilling and 30-50 kg/ha for broadcast are recommended as the optimal (9). In general, 10-20% higher rates ought to be considered in areas where moisture supplies are higher (water-logged conditions) or where weeds may be a problem. Satisfactory yields of linseed can be obtained by broadcasting (Table 8), but sowing in rows is better for ease of weeding and harvesting. At Kulumsa, close row spacing of 19 cm produced higher mean seed yields than the wider row spacing of 38 cm when a seed rate of 25 and 50 kg/ha was used (Table 9).

Linseed is adapted to nutrient deficient conditions and it usually responds poorly to the application of fertilizer under low standard of husbandry. However, there are indications of location by fertilizer interactions. The application of fertilizers particularly nitrogen was important in water logged soils or where moisture supplies are high (9). The slight response in the national variety trials can justify the application of the lowest level of

Table 7. Results of linseed sowing date trials conducted at Kulumsa, Holetta and Ghinchi in different years (3,4,9,14)

Sowing date	Mean seed yield, (kg/ha) of soil								
	Red				Alluvial	Black			
	Kulumsa		Holetta		Illala	Holetta		Ghinch	
	1968	1969	1967	1970-71	1981	1967	1970-71	1974	1975
Early June	-*	-	575	-	-	940	-	-	-
Mid June	-	-	-	1251	655	-	1125	-	-
Late June	-	1393	948	1135	708	1006	1174	360	-
Early July	1090	1057	-	1164	727	-	1324	310	995
Mid July	841	-	920	966	341	1075	1269	150	830
Late July	808	673	734	-	-	717	-	-	-
Mid August	-	-	352	-	-	740	-	-	-
Late August	-	-	130	-	-	255	-	-	-
Mean	913	1041	610	1129	608	788	1223	273	913

* Information not available.

Table 8. Effect of hand weeding in broadcast and drilled linseed, Kulumsa 1968 and 1969 (3,4)

Sowing method	Seed yield, kg/ha							
	Frequency of hand weeding							
	0		Once		Twice		Mean	
	1968	1969	1968	1969	1968	1969	1968	1969
Broadcast	-*	160	810	630	1010	720	910	503
Drill	-	130	990	640	1070	610	1030	460
Mean	-	145	900	635	1040	665	970	482

* Information not available.

Table 9. Effect of row spacing and seed rate on seed yield of linseed at Kulumsa, 1967 season (2).

Seed rate (Kg/ha)	Seed yield kg/ha		
	Spacing between rows (cm)		
	19	38	Mean
25	1240	1040	1140
50	1260	980	1120
100	1030	1100	1065
Mean	1177	1040	1108

fertilizer (perhaps 23/23 kg/ha of N and P_2O_5) (Table 1).

Linseed is ripe when 90% of the bolls turn brown. Delaying harvest can allow seeds to weather and germination is reduced.

Crop protection

The main aim of cultural practices should be the destruction of weeds.

The seed used by farmers for sowing is an important source of weed infestation. Linseed is a poor competitor with weeds at all growth stages. However, in its late stage, the leafiness and height of the cultivar are important agronomic characters in its competitiveness (19). The average yield loss due to weed competition in linseed under Holetta and Mekele conditions was found to be 62.2 and 53.1%, respectively (22). An early weeding, 21 days after emergence followed by mid-season weeding is the minimum number of weeding necessary. However, if the weed population is low, a single early weeding is the most cost effective. Among the herbicides tested at Holetta, Linuron 50 WF at 1.0-1.5 kg a.i/ha and Metobromuron 50 WP at 2.0 kg a.i/ha as pre-emergence treatments and MCPA 40% at 1.2 kg a.i/ha as post-emergence were found to be effective in linseed. However, large-scale testing of these herbicides is advisable before final recommendation is made (23).

Linseed is used in rotation to prevent disease build up as linseed is immune to diseases that attack cereals. At Holetta, high yields of wheat, barley, teff and rapeseed following linseed, have been obtained (9). Disease in Ethiopia may be serious problem where linseed is grown in high rainfall areas, or where the soil is poorly drained. There are many organisms known to be pathogenic on linseed, nine have been recorded in Ethiopia (Table 10). The main diseases are pasmo, wilt, seedling blight and powdery mildew (6, 20). Warm humid weather favours the spread of pasmo. Crop rotation and burning of infected straw can help control of pasmo (13). With regard to Fussarium wilt, high soil temperature (above 25^{0}C) and low soil moisture generally favour the development of the disease (13). The wilt screening activities have been successful in identifying resistance to wilt. The technique for resistance screening against wilt has been worked out and there are varieties, lines and crosses which appear to have high level of resistance.

Four species of insect pests have been recorded, but only two are economically important (Table 11). These are african bollworm and golden plusia. African bollworm is the most serious insect pest (6,18). The use of Endosulfan 39% E.C. at a rate of 2 l/ha or 3.4 l/ha of DDT 25% E.C. is effective to control the bollworm (13). The following four insecticides are found effective in controlling plusia worms (13).

1) Femitrothion 50% E.C. @1.5-2.0 l/ha
2) Carbaryl 85% WP @1.5 kg/ha
3) Malathion 50% E.C. @2 l/ha
4) DDT 25% E.C. @3-4 l/ha.

Table 10. Diseases of linseed recorded in Ethiopia (20).

Disease	Pathogen	Status
---	*Cladosporium* spp	Unknown
Anthracnose	*Colletotrichum linicolum* Pethyb and Loff	Minor
Wilt	*Fusarium* spp	Major
---	*Helminthosporium sativum* Pam., King and Bakke	Unknown
Rust	*Melampsora lini* (DC.) Tul.	Minor
Garcia-roda	*Mycosphaerella linorum* (Wollenw)	Unknown
Powdery mildew	*Odium* spp	Major
Seedling blight	*Rhizoctonia solani* Kuchn.	Major
Pasmo	*Septoria linicola (Speg.)* Garassini	Major

Table 11. Insect species recorded on linseed in Ethiopia (18).

Common name	Scientific name	Status
Flea beetle	*Haltica pyritosa* (Erickson)	Minor
Blue bug	*Calidea duodecimpunctata* (Fabricius)	Minor
African bollworm	*Heliothis armigera* (Hubner)	Common
Golden plusia	*Diachrusia orichalcea* (Fabricius)	Sporadic

Verifications

On-station verification

The station verification trials over two years showed convincingly that the released varieties and the production package give good yields (Table 12). This means that by improving the practice the productive capacity of the varieties can be utilized and considerable yield can be obtained.

Table 12. Summary of seed yield in kg/ha of the released varieties in the linseed station verification trials grown at two research sites in two ADZ 1985-1987 (Unpublished)

Variety	Holetta Research Center (Central) 3 years	Adet Research Center (North-western 1 year)
CI-1525	1378	1800
CI-1652	1345	2140
Mean	1362	1970

On-farm trials

The on-farm trials are designed to verify and check performance and acceptability of research recommendations. This activity was carried outside of research centers on representative farmers' field. From the surveys, it was found out that most farmers do not weed at all and those who do, make one or seldom two hand weeding when convenient. Certainly, in Ethiopia the crop is broadcast at varying seed rate without fertilizer. Hence, the linseed on-farm trials were conducted comparing the recommended varieties, fertilizer, weeding and seed rate combination with the farmers methods mentioned above. In general, the optimum package gave substantial yield increase over farmers' practice. Management is very critical (1,12). Across locations, both the local and improved varieties gave higher yields where the improved technologies were properly implemented as compared to the traditionally managed fields (Table 13).

Table 13. Mean seed yield in kg/ha of two released and one local variety in the linseed on-farm trials grown at three ADZ using farmers' method and researcher's package, 1985-1987 (1,16)

Agricultural Development Zone	Number of sites	Farmers' method			Researcher's package		
		CI-1525	CI-1652	Local	CI-1525	CI-1652	Local
Central	20	738	748	658	982	974	894
North western	18	457	483	357	680	740	523
Mean	38	598	616	508	831	857	709

Production demonstration

Linseed had been shown to give high yield under pilot-cum-demonstrations. On such 1/2 ha demonstration, 700 kg/ha was a common figure (Table 14).

Table 14. Seed yield in kg/ha of linseed varieties grown in production at three locations in two ADZ 1987-1988 (Unpublished)

		Management		Advantage	Increase
Zone	Site	Local	Improved	(kg/ha)	(%)
Central	Arbi Gebeya	430	730	300	69.8
South eastern	Digelu	470	720	250	53.2
	Gonde	-	790	-	-

Conclusion

Great strides have been made in linseed research since the birth of the oilseed improvement program. Marked increases in yield of linseed were achieved by applying a package of recommendations including superior varieties, optimal doses of fertilizer and timely sowing and weeding. One weeding can raise the yield from a complete uneconomical level to a considerable better return. On the other hand, several trials demonstrated that linseed is definitely the choice for poor soils. In future, more emphasis will be placed on popularizing the improved production technology to farmers through a large number of pilot-cum-production demonstrations in farmers' field and through training programs.

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