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YIELD AND AGRONOMIC TRAITS PERFORMANCE OF LINSEED GENOTYPES *(LINUM USITATISSIMUM L)* IN CENTRAL HIGHLANDS OF ETHIOPIA

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Abstract: **The experiment was executed to test seed yield and agronomic traits performance of linseed in central highlands of Ethiopia. The experiment was laid out in Randomized Complete Block Design with three replications at Holetta, Bekoji, Kulumsa and Asasa Agricultural Research Centres. The results of combined analysis indicated that studied traits of genotypes for seed yield and agronomic performance of linseed traits were highly and significantly different for all traits compared. This revealed that there was a considerable magnitude of variability among the different genotypes for all the traits. Among the tested genotypes, PGRC/E 10306 X Chilalo Y/3(1797kg/ha), Omega X CI -1525/B/44(1586kg/ha), Omega X CI -1525/Y/44(1559kg/ha) and CI -1652 X Omega /B/53(1529kg/ha) scored first, second, third and fourth respectively, in seed yield. The overall agronomic performances of the tested linseed genotypes in each location as explained by the locations mean indicated that Bekoji has the highest seed yield followed by Holleta and Kulumsa with a mean yield of 2034,1558, and 1271 kg/ha, respectively. The mean performance of three genotypes PGRC/E 10306 X Chilalo Y/3 (692kg/ha), Omega X CI -1525/B/44 (599kg/ha) and Omega X CI -1525/Y/44 (595kg/ha) was first, second and third, respectively in mean oil yield. The mean agronomic performance of ten genotypes of linseed for six different traits studied showed a wide range and displayed a good distribution within the range. Date of flowering differences ranged from 87days to 91 days. On the other hand date of maturity differences ranged from 148 days to 159days and on other side plant height shown the differences ranged from 84cm to 100cm in the locations mean tested.**

Therefore these traits can serve as performance indices in genetic improvement of linseed yield and its agronomic component traits.

Keywords: **agronomic traits, correlation, genetic variability, heritability, linseed, path analysis.**

1. INTRODUCTION

In Ethiopia Linseed (Linum usitatissimum L.) is one of the most important oldest plant species cultivated for seed yield and oil traits. In Ethiopia, among the highland oilseeds, linseed stands second next to niger seed in total production and areas coverage (CSA, 2017.18). Adugna also reported this crop as it is the second most important oil crop of Ethiopia in terms of area and production (Adugna, 2000). Linseed has been cultivated in Ethiopia since antiquity (Adefris *et a l*, 1992). It grows well in either a heavy sandy loam or light clay soils with a good drainage system (Getinet and Nigussie, 1997). The crop is traditionally used for many purposes, such as source of food, feed, fiber, oil, medicine, industrial raw material and export commodity. The crop is traditionally grown on marginal and sub-marginal lands with minimum frequency of plowing and no weeding (Adefris *et al.,* 1992). The crop is well adapted to cool, long growing season and high rainfall areas at elevation between 1600 and 2800 meters and best performed at elevation between 2200 to 2800

meters above sea level. The national average productivity and oil content is low as compared to some of potentially high yielding varieties developed in research center. Under such a situation it becomes very important to identify genotypes which can show best performance in seed yield and oil content over different environments or locations. Only best performing genotypes can guarantee a good yield and oil content with decreased risk of losing production and allow the plant breeders to make general recommendations. Keeping these facts in to consideration, the present investigation was carried out by considering ten linseed genotypes comprising one standard check to test seed yield and agronomic performance of linseed traits in central highlands of Ethiopia.

2. MATERIALS AND METHODS

Experimental Sites

The experiment was conducted in experimental field at Holetta, Bekoji, Kulumsa and Asasa Agricultural Research Centre s during 2008/09 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 test seed yield and agronomic performance of linseed traits in central highlands of Ethiopia. A seed rate of 25kg/ha was utilized to conduct the experiment. Two-hand weeding and fertilizer rate of 23/23 N/P_2O_5 Kg ha^{-1} was the inputs of improved packages used for assessment purpose on each individual experimental plot. Randomized Complete Block Design with three replications was employed. The gross plot size was six-meter square (six rows of 5meter long and 20 cm spacing) and the net harvest plot size was four-meter square (four central rows). The four central rows in each plot were used for data recording. By considering the central four rows the pre harvested agronomic data such as 50% date of flowering, and 50% date of maturity was recorded. In addition to this plant height of this trait per five plants was collected. Besides pre harvested data, post harvest agronomic data such as, seed yield which was obtained from the central four rows, oil content that was measured by using Nuclear Magnetic Resonance spectroscope and oil yield that was also obtained by multiplying seed yield with corresponding oil percentage were taken and statistically analysed using SAS soft ware. Major criteria during the assessment considered were yield and oil production enhancing agronomic component traits.

Description of Test Materials

A total of ten Linseed genotypes that include one standard check (Tolle) were used in this study. The name of the genotypes used in the experiment are given in Table1.

Table 1: List of Ten Linseed genotypes used in the study area in 2008 cropping season

No.	Name of genotypes
1	PGRC/E 10306 X Chilalo Y/3
2	PGRC/E 10306 X CI -1525/3/B
3	Omega X CI -1525/Y/44
4	PGRC/E 10306X CI-1525/1/A
5	CI -1652 X Omega /B/53
6	Omega X CI -1525/14/A
7	Omega X CI -1525/Y/43
8	CI-1652 X Omega/B//58
9	Omega X CI 1525/B/44
10	Tolle

Experimental Design, Management and Season

The experiment was executed from June 2009 to December 2009. The experiment was laid out in Randomized Complete Block Design with three replications. A plot of four central rows each five -meter long and 30cm spacing between rows were used for data collection. Each replication was represented by ten plots. The path between replication was 1.5 m and the spacing between plots within was also 0.4 m. Each plots was manually drilled, a rate of 25 kg/ha and urea and phosphorous fertilizers were applied at the rates of 23/23 kg/ha N/P_2O_5, respectively following the national recommendations.

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Data Collected

I. data collected on plot basis

1. Days to flowering (Df): The numbers of days from date of sowing to a stage at which 50% of the plants in a plot open flowers.

2. Days to maturity (Dm): The number of days from date of sowing to a stage at which 50% of the plants have reached physiological maturity. It is the time when 50% of the capsules change their color into brown.

3. Seed yield per plot (SYPP): Seed yield per plot measured in grams after moisture of the seed was adjusted to 7 percent.

4. Oil content (Oc): The proportion of oil in the seed to total oven dried seed weight

measured by nuclear magnetic resonance.

5. Oil yield (Oy): The amount of oil in grams obtained by multiplying seed yield per plot

by corresponding oil percent.

II. On plant basis

This data was collected from five plants randomly selected from the central rows of each plot and averaged for statistical analysis.

Plant height (PHT): The average height of five randomly selected plants was measured in centimeters from the ground surface to the top of the main stem at maturity.

3. RESULTS AND DISCUSSION

The results of combined analysis of mean squares of variance are presented in Table 2. The result indicated that studied traits of genotypes for seed yield and its related agronomic component traits were highly and significantly different for seed yield per plot, oil content percent and oil yield kg/ ha, date of flowering, date of maturity and plant height. This revealed that there was a considerable magnitude of variability among the different genotypes for all the traits compared. It provides ample scope for selection of different quantitative and qualitative traits for yield improvement in linseed. Similar findings were reported by Akbar *et al*. (2003). The high amount of genetic variability in the studied genotypes for the major yield contributing traits along with oil content and oil yield indicated that the possibility of further improvement of these traits. Yadava, 1996 reported similar findings pertaining to the presence of high genetic variability for different traits including seed yield per plant.

Table 2: The mean squares for different sources of variation and the corresponding Coefficient of variation in percent for the six traits studied

Traits	Replication(2)	Genotype (9)	Error (72)	CV
Seed yield	0.125	277875**	53071.08	15.64
Oil content	0.027	8.02052**	0.02413	0.42
Oil yield	50803	51847.7**	7271.41	15.35
Date of flowering	6.425	26.2602**	2.84167	1.88
Date of maturity	8.1083	20.1528*	8.67315	1.95
Plant height	14.1667	136.6306**	19.759259	4.77

**,* Indicate significance at 0.01, 0.05 probability level:, figures in parenthesis refer to degrees of freedom, CV: Coefficient of variation

Analysis of variance for seed yield at Holetta and Kulumsa research locations showed significant ($p \leq 0.05$) variations among the genotypes, but non-significant at Bekoji and Asasa, respectively (Table 3). Among the tested genotypes, PGRC/E 10306 X Chilalo Y/3(1797kg/ha), Omega X CI 1525/B/44(1586kg/ha), Omega X CI 1525/Y/44(1559kg/ha) and CI -1652 X Omega /B/53(1529kg/ha) scored first, second, third and fourth, respectively in seed yield. The lowest yield across locations was for PGRC/E 10306X CI-1525/1/A (1289kg/ha). Eight genotypes also gave highest seed yield kg/ha than the standard check (Tolle). The overall agronomic performances of the tested linseed genotypes in each location as explained

by the locations mean indicated that Bekoji has the highest seed yield followed by Holleta and Kulumsa with a mean yield of 2034,1558, and 1271 kg/ha, respectively. This showed that Bekoji was the most favorable area for growing linseed followed by Holleta, and the least was Asasa.

Table 3: Mean seed yield of linseed genotypes across locations in 2008 crop season

No	Genotype	Holetta	Bekoji	Kulumsa	Asasa	Mean
1	PGRC/E 10306 X Chilalo Y/3	1642	2466	1734	1344	1797
2	PGRC/E 10306 X CI 1525/3/B	1472	1880	1209	922	1371
3	Omega X CI 1525/Y/44	1698	2314	1230	992	1559
4	PGRC/E 10306X CI-1525/1/A	1219	2061	1287	588	1289
5	CI -1652 X Omega /B/53	1855	2001	1243	1015	1529
6	Omega X CI -1525/14/A	1523	1911	1278	1102	1454
7	Omega X CI -1525/Y/43	1491	1863	1119	1103	1394
8	CI-1652 X Omega/B//58	1415	2094	1172	1100	1445
9	Omega X CI 1525/B/44	1765	2047	1263	1267	1586
10	Tolle	1497	1701	1175	838	1303
	Mean	1558	2034	1271	1027	1472
	CV (%)	10.5	13.8	9.8	14.74	15.65
	LSD (5%)	281.6	NS	213.7	NS	187.48

Analysis of variance for oil percent in each locations except Asasa showed significant ($p \leq 0.05$) variation (Table 4). Mean oil content at Holetta ranges 39.0 % for CI-1652 X Omega/B//58 to 41.9% for PGRC/E 10306 X Chilalo Y/3. At the same side mean oil content at Bekoji ranges 35.4 % for standard check Tolle to 38.8% for PGRC/E 10306 X Chilalo Y/3. Mean while Mean oil content at Kulumsa ranges 35.4 % for Tolle to 38.0% for CI -1652 X Omega /B/53. On other side mean oil content percentage at Asasa ranged from 32.4% for Tolle to 36.0% for Omega X CI 1525/B/44.Over all the oil content percentage for the tested genotypes was high at Holetta and least at Asassa with mean oil percentages of 40.5 and 34.5, respectively (Table 4). None of genotypes showed less mean performance of oil percentage than the standard check.

Table 4: Mean oil content of linseed genotypes across locations in 2008 crop season

No	Genotype	Holetta	Bekoji	Kulumsa	Asasa	Mean
1	PGRC/E 10306 X Chilalo Y/3	41.9	38.8	37.1	35.7	38.4
2	PGRC/E 10306 X CI 1525/3/B	40.9	37.7	37.1	35.7	37.9
3	Omega X CI 1525/Y/44	41.2	37.5	37.5	35.4	37.9
4	PGRC/E 10306X CI-1525/1/A	39.9	36.9	36.8	33.3	36.7
5	CI -1652 X Omega /B/53	41.4	38.0	38.0	35.5	38.2
6	Omega X CI -1525/14/A	40.9	37.1	36.7	34.5	37.3
7	Omega X CI -1525/Y/43	40.9	37.5	37.3	34.6	37.6
8	CI-1652 X Omega/B//58	39.0	37.5	36.1	34.2	36.7
9	Omega X CI -1525/B/44	39.5	37.6	37.6	36.0	37.7
10	Tolle	39.7	35.4	35.4	32.4	35.7
	Mean	40.5	37.4	36.9	34.5	37.3
	CV (%)	0.4	0.5	0.3	0.4	37.4
	LSD (5%)	0.27	0.3	0.22	NS	0.42

Similarly as of oil content, analysis of variance for oil yield in each locations except Asasa showed significant ($p \leq 0.05$) variation at Holetta, Bekoji and Kulumsa (Table 5).

Mean oil yield at Holetta ranges 486kg/ha for PGRC/E 10306X CI-1525/1/A to 768 kg/ha for CI -1652 X Omega /B/53. At the same side mean oil yield at Bekoji ranges 602kg/ha for standard check Tolle to 958 kg/ha for PGRC/E 10306 X Chilalo Y/3. Mean oil yield at Kulumsa ranges 416kg/ha for standard check Tolle to 643kg/ha for PGRC/E 10306 X Chilalo Y/3. Mean while Mean oil yield at Asasa ranges 271kg/ha for Tolle to 480kg/ha for PGRC/E 10306 X Chilalo Y/3. Over all the oil yield for the tested genotypes was high at Bekoji and least at Asassa with mean oil yield kg/ha of 762 and 358, respectively (Table 5).

The mean performance of three genotypes PGRC/E 10306 X Chilalo Y/3 (692kg/ha), Omega X CI 1525/B/44 (599kg/ha) and Omega X CI- 1525/Y/44 (595kg/ha) was first, second and third, respectively in mean oil yield. These genotypes gave the highest oil yield than the standard check, Tolle. None of genotypes showed less mean performance of oil yield than the standard check.

Table 5: Mean oil yield of linseed genotypes across locations in 2008 crop seasons

No	Genotype	Holetta	Bekoji	Kulumsa	Asasa	mean
1	PGRC/E 10306 X Chilalo Y/3	688	958	643	480	692
2	PGRC/E 10306 X CI 1525/3/B	602	708	449	329	522
3	Omega X CI 1525/Y/44	700	868	462	351	595
4	PGRC/E 10306X CI-1525/1/A	486	761	474	196	479
5	CI -1652 X Omega /B/53	768	760	473	360	590
6	Omega X CI -1525/14/A	623	710	469	380	546
7	Omega X CI -1525/Y/43	609	699	418	382	527
8	CI-1652 X Omega/B//58	552	784	423	376	534
9	Omega X CI 1525/B/44	698	769	474	456	599
10	Tolle	594	602	416	271	471
	Mean	632	762	470	358	556
	CV (%)	10.6	13.8	9.8	14.75	15.35
	LSD (5%)	114.9	180	79.2	Ns	69.39

The mean agronomic performance of ten genotypes of linseed for six different traits studied at Holeta, Bekoji, Kulumsa and Asasa locations showed a wide range and displayed a good distribution within the range as shown in Table 6. Date of flowering differences ranged from 87(for genotype Omega X CI- 1525/B/44) days to 91 days (for genotypesPGRC/E 10306 X CI 1525/3/B and CI -1652 X Omega /B/53 and Tolle). On the other hand date of maturity differences ranged from 148 days(for genotype Tolle) to 159days(for the genotype PGRC/E 10306 X Chilalo Y/3**)** and on other side plant height shown the differences ranged from 84cm(for the genotype Tolle) to 100cm(for genotype Omega X CI 1525/B/44) in the locations mean tested. Besides these traits studied seed yield in kg/ha ranged from 1289kg/ha (for Genotype PGRC/E 10306X CI-1525/1/A) to 1797kg/ha (PGRC/E 10306 X Chilalo Y/3). On the other hand oil content percent ranged from 35.70 %(for the genotype Tolle) to 38.39 %(PGRC/E10306 X Chilalo Y/3). Similarly oil yield kg/ha shown the difference ranged 471 kg/ha (for the variety Tolle) to 692 kg/ha (for the genotype PGRC/E 10306 X Chilalo Y/3), respectively.

Table 6: Mean agronomic performance of ten genotypes of linseed for six different traits studied at Holetta, Bekoji, Kulumsa and Asasa agricultural research centres during 2008/09 cropping season

No	Genotype	Seed yield kg/ha	Oil content %	Oil yield kg/ha	Days to		Plant height Cm
					Flowering 50%	Maturity 50%	
1	PGRC/E 10306 X Chilalo Y/3	1797	38.39	692	87	159	93
2	PGRC/E 10306 X CI 1525/3/B	1371	37.84	521	91	151	95
3	Omega X CI 1525/Y/44	1559	37.39	595	89	151	92
4	PGRC/E 10306X CI-1525/1/A	1289	36.73	479	90	150	91
5	CI -1652 X Omega /B/53	1529	38.21	590	91	149	97
6	Omega X CI -1525/14/A	1457	37.29	545	89	150	96
7	Omega X CI -1525/Y/43	1394	37.58	527	90	150	97
8	CI-1652 X Omega/B//58	1445	36.69	534	90	149	94
9	Omega X CI 1525/B/44	1585	37.65	599	87	151	100
10	Tolle	1303	35.70	471	91	148	84
	Mean	1472	37.4	556	90	150	93
	CV (%)	15.65	0.42	15.35	1.88	1.95	4.44
	LSD (5%)	187.48	0.08	69.39	1.37	1.51	2.88

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4. CONCLUSION

In this study ten linseed genotypes were evaluated in Randomized Complete Block Design with three replications at Holetta , Bekoji, Kulumsa and Asasa Agricultural Research Centers, in central highlands of Ethiopia, with the objective of testing for seed yield and agronomic performance of linseed traits in central highlands of Ethiopia. The analysis of variance showed the presence of highly significant differences among the tested genotypes for all of characters studied, indicating the existence of genetic variability among the tested genotypes for these characters. Analysis of variance for seed yield at Holetta and Kulumsa research locations showed significant ($p \leq 0.05$) variations among the genotypes, but non-significant at Bekoji and Asasa, respectively (Table 3). Among the tested genotypes, PGRC/E 10306 X Chilalo Y/3(1797kg/ha), Omega X CI 1525/B/44(1586kg/ha), Omega X CI 1525/Y/44(1559kg/ha) and CI -1652 X Omega /B/53(1529kg/ha) scored first, second, third and fourth respectively, in seed yield. Analysis of variance for oil percent in each locations except Asasa showed significant ($p \leq 0.05$) variation. Mean oil content at Holetta ranges 39.0 % for CI-1652 X Omega/B//58 to 41.9% for PGRC/E 10306 X Chilalo Y/3. Over all the oil content percentage for the tested genotypes was high at Holetta and least at Asassa with mean oil percentages of 40.5 and 34.5, respectively. None of genotypes showed less mean performance of oil percentage than the standard check. Similarly as of oil content, analysis of variance for oil yield in each locations except Asasa showed significant ($p \leq 0.05$) variation at Holetta, Bekoji and Kulumsa .Over all the oil yield for the tested genotypes was high at Bekoji and least at Asassa with mean oil yield kg/ha of 762 and 358, respectively.

The mean performance of three genotypes PGRC/E 10306 X Chilalo Y/3 (692kg/ha), Omega X CI 1525/B/44 (599kg/ha) and Omega X CI- 1525/Y/44 (595kg/ha) was first, second and third, respectively in mean oil yield. These genotypes gave the highest oil yield than the standard check, Tolle. None of genotypes showed less mean performance of oil yield than the standard check. The mean agronomic performance of ten genotypes of linseed for six different traits studied showed a wide range and displayed a good distribution within the range. Date of flowering differences ranged from 87days to 91 days. On the other hand date of maturity differences ranged from 148 days to 159days and plant height shown the differences ranged from 84cm to 100cm in the locations mean tested. Besides these traits studied seed yield in kg/ha ranged from 1289kg/ha (for Genotype PGRC/E 10306X CI-1525/1/A) to 1797kg/ha (PGRC/E 10306 X Chilalo Y/3). On the other hand oil content percent ranged from 35.7 %(for the genotype Tolle) to 38.39 %(PGRC/E 10306 X ChilaloY/3). Similarly oil yield kg/ha shown the difference ranged 471 kg/ha (for the variety Tolle) to 692 kg/ha (for the genotype PGRC/E 10306 X Chilalo Y/3), respectively. Therefore these traits can serve as selection indices in genetic improvement of linseed yield and its agronomic component traits.

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