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Estimates of Heritability, Genetic and Principal Components Analysis for Yield and its Traits in Linseed Genotypes (*Linum Usitatissimum L.*) in Central Highlands of Ethiopia

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ABSTRACT

The experiment was executed to estimate heritability, genetic advance and principal component analysis for yield and its traits in Linseed genotypes at Holetta agricultural research center, Ethiopia. Twenty-five genotypes of linseeds were analyzed using seed and agronomic traits in order to estimate heritability, genetic advance and major principal component traits that exist in these materials. The experiment was carried out in a simple lattice design. The analysis of variance showed that there were significant differences among genotypes for all traits compared except plant height. The significant difference indicates the existence of high heritability, genetic advance among the genotypes that is important for selection and breeding. The highest heritability in broad sense was recorded for oil content percent (47.98%), days to flowering (41.23%), seed yield (31.56%), oil yield (30.51) and days to maturity (30.35%). This suggests that large proportion of the total variance was due to the high genotypic and less environmental variance. Hence, a good progress can be made if some of these traits are considered as selection criteria for the improvement of yield and yield component traits. Principal component analysis showed that 100% of the variation was contributed by the first seven principal components for seed yield and its agronomic traits. Oil yield, plant height and stand percent were the major seed yield positive contributors of the variation in the first principal component in which 38.10% of the variation revealed. The present study revealed the presence of considerable high principal component contributor traits among genotypes for oil yield, plant height and stand percent traits analyzed. Therefore, these traits can serve as selection indices in genetic improvement of linseed yield and its component traits.

Keywords: *linseed, heritability, Genetic advance, Principal component analysis*

INTRODUCTION

In Ethiopia, among the highland oilseeds, Linseed (Linumusitatissimum L.) stands second next to niger seed in total production and areas coverage (CSA, 2017/18). Its area and production are estimated to 79044.51 hectares and 88209.65 tones, respectively, at private peasants' holdings level, with an average productivity of 1.116 tons/ha (CSA, 2017/18). It is often grown on well-drained and organic matter rich soils or by using inorganic fertilizer. Ethiopian linseed is well adapted to cool, long growing season and high rainfall areas at elevation between 2200 and 2800 meters. In these areas, the temperature and rainfall range from 12 to 18°C and 500 to 1200 mm, respectively during the main growing season. 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. Linseed cake is rich in microelements, vitamins, dietary cellulose, proteins (up to 38%) (Altai, 2010). 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 (micro-nutrients 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, Goyal and Kumar, (1991). The plant breeder needs to know the estimate of gene effects in order to plan for an effective breeding method for the improvement of the desired traits. Moreover, the type of breeding method to employ for the genetic improvement of yield and its components depends upon the type of gene action controlling the inheritance of the traits. Knowledge on the nature of the combining ability effects and their resulting variances, is the opening line in the preparation for breeding towards improvement of crop species. Therefore, the present study was executed to estimate broad sense heritability, genetic advance and principal component analysis for seed yield and its attributing traits in twenty-five Ethiopian linseed genotypes.

Materials and Methods

Experimental Site

The experiment was conducted at Holetta Agricultural Research Center (HARC) in 2008/2009 cropping season from June 2008 to December 2008. Holetta (West Shewa Zone of Oromia Region) is located at latitude 9º N and longitude 38º E, altitude of 2400 m a.s.l situated 30km West of Addis Ababa. It is one of the representatives of oil seed Linseed growing areas in the central highlands of Ethiopia (Nigussie and Mesfin, 1994). The area has average annual rainfall of 1059 mm and temperatures of 23ºC (maximum) and 8ºC (minimum). The soil type is Nitisols with soil ph in the range of 6.0 -7.5(Nigussie and Mesfin, 1994)

Description of test Materials

A total of twenty-five linseed genotypes that include one standard check (kulumsa-1) were used in this study. The genotypes were maintained at Holetta agricultural research center of highland oil crops improvement project. The genotypes used in the experiment are given in Table 1.

Experimental Design, Management and Season

The experiment was executed from June 2008 to December 2008. The experiment was laid out in simple lattice design with two replications. A plot of four central rows each one-meter point two long and 20cm spacing between rows were used for data collection. Each replication had five blocks and each block was represented by five plots. The path between blocks was 1.5 m and the spacing between plots with in sub-blocks was also 0.4 m. Each entry 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. All other recommended agronomic and cultural practices were carried out following practices described by Adefris (2005).

Table1. *List of twenty-five Ethiopian linseed genotypes used in the study*

No	Treatments
1	CDC1747XCI-1652/S1
2	CDC1747XCI-1652/S4
3	R12-N27GXCI-1525/S6
4	CI-1525 X CDC1747/S2
5	R12-N27GXCI-1525/S2
6	CI-1525 X R12-D33C/S2
7	CI-1525 X CDC1747/S4
8	R12-N27G X CI-1525/S4
9	CI-1525 XCDC1747/S5
10	R12-N27G X CI-1525/S8
11	CI-1525 X R-12N27G/S13
12	CI-1525 X R-12N27G/S4
13	CDC-1747 X CI-1652/S17
14	CI-1525 X R-12N27G/S10
15	CDC1747 X CI-1652/S15
16	CI-1525 X R12-N27G/S12
17	R12-N27G X CHILALO/S4
18	Omega x CI-1525/B/3
19	CI-1525 X R12-D33C/S15
20	PGRC/E 10306 X Chilalo/y/1
21	PGRC/E 10306 X Chilalo/y/2
22	PGRC/E 10306 X Chilalo/B/2
23	PGRC/E 10306 X Chilalo/B/4
24	CI-1652 X CDC1747/S3
25	Kulumsa-1

Data Collected

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

Oil Content (Oc): The proportion of oil in the seed to total oven dried seed weight measured by nuclear magnetic resonance spectroscope as described by Oregon State University seed laboratory.

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

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 flower.

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.

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.

Stand Percent (SP): The proportion of plants at vegetative stage and at harvest as visually assessed in percentage.

Results and Discussion

The analysis of variance for the seven traits studied is given in Table 2. The analysis of variance showed that there were significant differences among genotypes for all traits compared except plant height.

The significant difference indicates the existence of genetic variability among the genotypes that is important for selection and breeding. Similarly, Yared and Mistiru, (2013) studied twenty-five linseed genotypes derived from various crosses for date of flowering, plant height and thousand seed weight of traits found the same result.

Genetic variability of linseed genotypes for days to flowering, days to maturity seed yield per plot, oil content and oil yield also has been reported by Adugna (2011).

Table2. *Mean squares for different sources of variations for seven genetic and morphological traits of linseed genotypes*

No.	Characters	Genotype (24)	Block (8)	Replication (1)	Intera-block error (16)
1	Seed yield kg/ha	110128*	132813.895	3595.5	24904
2	Oil content percent	0.9673**	0.02395	0.0162	0.01995
3	Oil yield kg/ha	49634*	64758.705	1425.8	12017
4	Date of flowering	13.337**	4.595	19.22	1.2825
5	Date of maturity	31.875**	21.345	11.52	7.795
6	Plant height	44.245ns	37.780	0.18	16.1925
7	Stand percent	49.388*	60.105	20.48	32.23

**, ** significant at p = 0.05 and 0.01 significance level, respectively.*

Heritability in the Broad Sense

Breeders can make rapid progress where heritability is high by using selection methods that are dependent solely on phenotypic characteristics (e.g. mass selection). However, where heritability is low methods of selection based on families and progeny testing are more effective and efficient. Heritability estimated using the total genetic variance is called broad sense heritability. Heritability in the broad sense of the traits is presented in Table 3. In this study, heritability values were found to be sufficiently high for most important yield component characters. Dabholkar (1992) generally classified heritability estimates as low (5-10%), medium (10-30%) and high (30-60%). Based on this classification, oil content percent (47.98%), days to flowering (41.23%), seed yield (31.56%), oil yield (30.51%) and days to maturity (30.35%), exhibited high heritability estimates. Oil content percent was found to be the most heritable trait in the genotype, with heritability of 47.98 %, followed by days to flowering (41.23%) and seed yield (31.56%). This indicates that selection for these traits in the genotype would be most effective for the expression of these traits in the succeeding generations. Therefore, good improvement can be made if some of these traits are considered as selection criteria in future breeding program. Similar findings had been reported by Adugna (2011) for seed yield, date of flowering, date of maturity and for thousand seed weight. High heritability value for thousand seed weight, date to flowering, days to maturity and plant height recorded in the current study was also recorded by Yared (2010) and Adugna (2011). According to Singh (1993), if the heritability of a character is high, selection for such character is fairly easy as selected character will be transmitted to its progeny. This is because there would be a close correspondence between the genotype and phenotype due to a relatively similar contribution of the environment to the genotype. At the same time only plant height (23.21%) and stand percent (10.51%) exhibited medium heritability estimates.

Genetic Advance

Concerning the genetic advance at 5% intensity the highest genetic gain was predicted for seed yield (14.95kg/ha) followed by oil yield (14.16kg/ha) while the lowest genetic advance was predicted for date of maturity (2.29). Genetic advance as a percent mean ranged from 0.242 % for seed yield to 3.723% for oil content (Table 3). Within this range, a relatively high genetic advance as a percent mean was observed for oil content (3.723%) and plant height (2.156%) and followed by date of flowering (1.953%). On the other side high genetic advance with high heritability was shown for seed yield per plot and oil yield which may be because of the presence of both additive and non-additive gene action (Liang *et al.*, 1972). Those traits having medium heritability along with better genetic advance could be improved using breeding procedure such as pedigree method. On the other hand, the lowest genetic gain as percent of means was observed for seed yield 0.242% followed by oil yield 0.342%. Low genetic advance as percent means observations in this study indicates that characters probably were under environmental influence than the genotypic expression and that selection based on these traits would be ineffective.

Table3. *Broad sense heritability and genetic advance and Genetic advance as percent of mean of studied traits*

No.	Traits	H2	GA=K*PV*H2	GA as means%
1	Seed yield	31.56	14.95	0.242
2	Oil content	47.98	2.37	3.723
3	Oil yield	30.51	14.16	0.342
4	Date of flowering	41.23	3.43	1.953
5	Date of maturity	30.35	2.29	0.878
6	Plant height	23.21	4.00	2.156
7	Stand percent	10.51	2.49	2.013

h2b = Broad sense heritability, GA = Genetic advance and K = Selection intensity

Principal Component Analyses

In order to assess the patterns of variations, principal component analysis (PCA) was done by considering seven traits for seed yield and agronomic traits. Principal component analyses are presented in Tables 4. Principal component analysis showed that 100.00% of the variation was contributed by the first seven principal components for agronomic traits. Oil yield, plant height and stand percent were the major seed yield positive contributors of the variation in the first principal component in which 38.10%of the variation revealed. Seed yield, oil yield and Plant height had relatively high positive weight. Date of 50% flowering had negative weight. Additional 29.94% variation in the second principal component was mainly observed through trait such as date of flowering, date of maturity and stand percent. The third principal component was accounted for another additional 14.86%of the variation in which oil content and plant height were the major contributor. Seed yield kg/ha had the highest negative weight. Principal component 4 and 5 contributed 8.43% and 5.59% additional variations, respectively. Oil content percent in principal component 4 and stand percent in principal component 5 were among the major contributors. Plant height in principal component 4 and date of maturity in principal component 5 had the most negative weight. Date of flowering and plant height in principal component 6 contributed 3.08 % additional variations and seed yield per plot in principal component seven are major variation contributor. In general, it is assumed that traits with larger absolute values closer to unity within the first principal component influence the clustering more than those with lower absolute values closer to zero (Chahal and Gosal, 2002). In this study, most of the traits individually contributed small effects (± 0.0001-0.7063) to the total variation and, therefore, differential grouping of genotypes was mainly attributed by the cumulative effect of the individual traits. However, traits which had relatively greater weight in the first principal component largely contributed to the total variation and they were accountable for differential grouping of genotypes.

Table4.*Component scores of the first seven principal components of twenty-five genotypes of linseed based on their agronomic traits*

No.	Traits	Scores of components						
		PCA1	PCA2	PCA3	PCA4	PCA5	PCA6	PCA7
1	Seed yield	0.5652	-0.1198	-0.2555	0.2093	-0.2421	0.0747	0.7021
2	Oil content	0.0148	-0.4001	0.6555	0.5649	0.2483	-0.1447	0.0910

3	Oil yield	0.5626	-0.1706	-0.1700	0.2823	-0.2084	0.0596	-0.7063
4	Date of flowering	0.1458	0.5781	0.1083	0.4953	-0.1170	0.6114	0.0023
5	Date of maturity	0.2076	0.5017	0.4441	-0.0894	-0.4765	-0.5224	-0.0019
6	Plant height	0.4409	0.0021	0.4836	-0.5362	0.2068	0.4914	0.0003
7	Stand percent	0.3242	0.4588	-0.1826	0.1285	0.7435	-0.2859	-0.0001
	Eigen value	2.6668	2.0960	1.04	0.5902	0.3915	0.2153	0.0002
	Variance %	38.1	29.94	14.86	8.43	5.59	3.08	0.00
	Cumulative	38.1	68.04	82.9	91.33	96.92	100.00	100.00

CONCLUSION

In this study, twenty-five linseed genotypes were evaluated in simple lattice design with two replications at Holetta Agricultural Research Center, West Shewa zone, with the objective of estimating broad sense heritability, genetic advance and principal component analysis for seed yield and its attributing traits in twenty-five linseed genotypes. The analysis of variance showed the presence of highly significant differences among the tested genotypes for the all of characters considered except plant height, indicating the existence of genetic variability among the tested genotypes for these characters.

Based on this classification, oil content percent, days to flowering, seed yield, oil yield and days to maturity, exhibited high heritability estimates. Oil content percent was found to be the most heritable trait in the genotype, followed by days to flowering and seed yield. This indicates that selection for these traits in the genotype would be most effective for the expression of these traits in the succeeding generations. Therefore, good improvement can be made if some of these traits are considered as selection criteria in future breeding program. Heritability in broad sense estimates were high for oil content percent, days to flowering, seed yield, oil yield and days to maturity.

Similarly, only the heritability values of plant height and stand percent exhibited medium estimates. Highest genetic gain was predicted for seed yield followed by oil yield while the lowest genetic advance was predicted for date of maturity. Genetic advance as a percent mean ranged from 0.242 % for seed yield to 3.723% for oil content. Genetic advance as percent of the mean (GAM) was high for oil content, plant height, followed by date of flowering and whereas the rest shows low GAM. Principal component analysis showed that 100.00% of the variation was contributed by the first seven principal components for seed yield and agronomic traits. Oil yield, plant height and stand percent were the major seed yield positive contributors of the variation in the first principal component in which 38.10% of the variation revealed. Additional 29.94% variation in the second principal component was mainly observed through trait such as date of flowering, date of maturity and stand percent.

The third principal component was accounted for another additional 14.86% of the variation in which oil content and plant height were the major contributor. Principal component 4 and 5 contributed 8.43% and 5.59% additional variations, respectively. Oil content in principal component 4 and stand percent in principal component 5 were among the major contributors.

Date of flowering and plant height in principal component 6 contributed 3.08 % additional variation and seed yield per plot in principal component seven was major variation contributor. However, traits which had relatively greater weight in the first principal component largely contributed to the total variation and they were accountable for differential grouping of genotype. Therefore, these traits can serve as selection indices in genetic improvement of linseed yield and its component traits.

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