

MULTIVARIATE ANALYSIS OF GENETIC DIVERSITY IN LINSEED GENOTYPES FOR YIELD AND ITS COMPONENT TRAITS

ABSTRACT

In the present investigation a total 30 linseed genotypes including released varieties were evaluated during *Rabi* 2021-22 at Agricultural Research Station, Ummedganj, Kota, Rajasthan (India) for understanding genetic diversity for grain yield and its component traits using principal component analysis. PCA was utilized to examine the variation and to estimate the relative contribution of various traits for total variability, first four principal components have more than one eigen values and accounted for 70.87% of total cumulative variance among 11 traits. PC1 had the contribution from traits *viz.*, days to maturity, plant height, capsule per plant, seed per capsule, plant stand, test weight, branches per plant, germination per cent and yield per plant, which accounted for 26.08% of the total variability whereas PC2, PC3 and PC4 exhibited 20.13%,13.43% and 11.23% to the total variability respectively. Thus, the results of principal component analysis revealed the wide genetic variation in linseed genotypes indicating that these accessions may be used as donors to improve the yield and quality traits in varietal development program. On the basis of Ward's linkage cluster analysis, five clusters were formed to identify relative closeness among 30 genotypes. Cluster V consisted of maximum 9 genotypes followed by cluster I and IV (8), cluster III (3) and cluster II (2). Maximum inter cluster distance was recorded between cluster I and IV indicating the possibilities of high heterosis if individual from these clusters were cross-bred. Cluster I had the highest mean values for plant height, seed per capsule, plant stand and yield per plant. Hence, suggesting that the genotypes constituted in these clusters may be used as a parent for future hybridization programs.

KEYWORDS: Cluster, Diversity, Eigen value, Linseed, Principal Component Analysis.

1. INTRODUCTION

“Linseed (*Linum usitatissimum* L. $2n=30$) also known as flax is a member of the genus *Linum* in the family Linaceae. It is one of the oldest crops being cultivated since the beginning of civilization. Every part of the linseed plant is utilized commercially, either directly or after processing” (Qamar *et al.*, 2019) Compared with other oil crops, linseed containing about 36-40

% oil is the richest source of polyunsaturated fatty acids (PUFA) like alpha-linolenic acid, the most abundant source of antioxidants (Andruszczak *et al.*, 2015 and Goyal *et al.*, 2014) and lignin (Kajla *et al.*, 2015), which has a beneficial effect on the prevention of the diseases and human health. “Due to its high (45–60%) linolenic acid content, which lends it drying and hardening properties, the oil is primarily employed in the industrial manufacture of paints, varnishes, soaps, and printing inks” (Wakjira, 2007 and Biradar *et al.*, 2016). However, a low linolenic acid content is required for human consumption. Keeping in view, the increasing demand for linseed due to numerous health benefits, there is a consistent need to increase the genetic potential for seed yield.

“In India it is grown in 181 thousand ha with a production of 41 thousand tones and productivity of 227kg/ha”(Anonymous,2020-21).“The area under linseed cultivation in Rajasthan is 5.7 thousand ha and production is 6.1 thousand tones with an average yield of 1066 kg/ha”(Anonymous, 2021).“The genotypes in the preceding cluster may be targeted for numerous crossing programs in order to develop transgressive segregates with better yield.Appropriate selection of the parents is essential to be used in crossing to enhance the genetic recombination for potential yield increase”(Islam *et al.*, 2004). “Genetic distance between parents is necessary to benefit transgressive segregation” (Joshi *et al.*, 2004). “Higher the genetic distance between parents, the higher heterosis in progeny can be observed” (Anand and Murty 1968).

“Principal Component Analysis (PCA) data consists of numerous intercorrelated quantitative dependent variables. It collects data from a table and displays it as a collection of new orthogonal variables. It might be used to identify trends and eradicate redundancy in data sets. It takes data from a table and portrays it as a set of new diagonal variables known as principle components” (Maji and Shaibu, 2012). “It constructs an Eigen vector for each axis, condenses the dimensions of a multivariate data set to a small number of primary axes, and gives component rankings for every character “(Leonard and Peter, 2009). “As observations it assesses data made up of several qualitative dependent variables that are associated”(Kaur *et al.*, 2018 and Mahendran *et al.*, 2015). “Instead,then representing each sample with amounts for thousands of variables, each sample can be portrayed with relatively few numbers by employing a few components” (Ringer, 2008). “As a result, the main advantage of PCA is its ability to quantify

the significance of each dimension for characterizing a data set's variability in more understandable and visually appealing dimensions by using linear arrangements of variables that account for the majority of the variation found in the initial set of variables. The more positive or negative the direction of the coefficients, the greater their efficacy they will be in differentiating between accessions, whereas Cluster approach, which relies on extended proximity, is a useful strategy for assessing genetic variation at the genotypic level”(Mahalanobis, 2015). “It has previously been demonstrated that multivariate analysis, which consists of PCA and cluster analysis, is a useful biometric method for assessing the level of diversity in a germplasm collection encompassing various crop plants” (Acquaah, 2012).As a result, the primary goal of this work was to estimate the possible genetic diversity by applying the PCA approach for parent selection in a hybridization program in order to obtain desired segregants in advanced generation. Multivariate statistical approaches are commonly used to summarize and characterize the intrinsic diversity among genotypes and to measure the degree of difference between the genotypes.

2. MATERIAL AND METHODS

The germplasm used in this study consisted of 30 linseed accessions (Table 1). The trial was conducted during *Rabi* 2021-2022 at Agricultural Research Station, Ummedganj, Kota, in Randomized Block Design (RBD) using three replications. Each entry had four rows of 3 m length, having a spacing of 30 cm between rows and 10 cm between plants. For each genotype, plant height (cm), capsule per plant, seed per capsule, plant stand, test weight (g), branches per plant and yield per plant (g) were determined on randomly selected five plants. On a full plot basis, days to 50% flowering, days to maturity and germination per cent were recorded. To uncover the best connections among features, R software was used to perform principal component analysis (PCA) and a hierarchical clustering.

3. RESULTS AND DISCUSSION

3.1 Principal component analysis

Principle Component Analysis revealed that out of eleven characteristics studied, only four principal components (PCs) exhibited more than 1.00 eigen value. ‘Eigen values’ quantify the significance and contribution of every component to entire variance, while each of the

coefficients of an eigen vector reflects the extent to which each original variable that each primary component is connected with has contributed to the total variance. There are no standard methods to demonstrate the relevance of Eigen values and the coefficients (Jolliffe, 2002), for the selection of various parents, the main components with more than one eigenvalue showed greater variability among the linseed genotypes. According to PCA, the first four PCs explained 70.87 per cent of the variation in yield and yield component attributes among 30 genotypes (Table 2). Scree plot elucidated the variation percentage between Eigenvalues and the Principal components (Fig. 1). Among the four principal components, PC1 shared high proportion of total variation 26.08% with an Eigenvalue of 2.86. In comparison to the other PCs, the graph clearly shows that PC1 showed the most variability. The rest of the three principal components *viz.*, PC2, PC3 and PC4 contributed 20.13%, 13.43% and 11.23% of the total variance respectively. The Eigen values are gradually declined from PC1 to PC4. The Eigen values are 2.21, 1.47 and 1.23 for PC2, PC3 and PC4, respectively. Elbow type line is obtained after PC4 tended to straight with minute difference observed in each PC. Similar results were earlier reported by (Dabalot *et al.*, 2020).

Results of rotated component matrix showed that the first principal component PC1 which accounted for the maximum variability was positively contributed by characters such as days to maturity (0.30), plant height (0.40), capsule per plant (0.48), seed per capsule (0.11), plant stand (0.00), test weight (0.15), branches per plant (0.38), germination per cent (0.14) and yield per plant (0.14), clearly indicated that the variation in PC1 is mainly due to these characters. Therefore, the genotypes extracted from PC1 might prove effective for improving the traits that lead to maximum diversity for subsequent breeding endeavors.

PC2 was positively contributed by characters *viz.*, days to 50% flowering (0.42), days to flowering (0.45), days to maturity (0.00), plant height (0.20), capsule per plant (0.15), plant stand (0.47), branches per plant (0.27) and germination per cent (0.47), while characters *viz.*, yield per plant (-0.03), test weight (0.06) and seed per capsule (0.09) showed negative loadings. PC3 had the positive contribution from the characters *viz.*, days to flowering (0.09), days to maturity (0.49), capsule per plant (0.06) and branches per plant (0.23), while remaining factors showed negative loadings. PC4 had the positive contribution from the characters *viz.*, days to 50% flowering (0.13), days to flowering (0.20), capsule per plant (0.19), seed per capsule (0.05), test

weight (0.79), branches per plant (0.19) and germination per cent (0.03). As a result, these four PCs may be used to choose the most varied accessions. Similar findings were published by (Worku et al., 2015; Kaur et al., 2018; Patial et al., 2019), confirming the independence of certain features.

The biplot diagram depicts the interplay of characteristics as well as the genotypes that perform superior for the traits. Each trait's vector length represents its contribution to overall divergence; the more extensive the vector length, the greater the contribution of the concerned traits. In this work, the biplot diagram (Fig. 2) between PC1 and PC2 depicts the spread and kind of variation for genotypes and quantitative features. The trait yield per plant (g) and capsule per plant showed maximum vector length indicating its contribution to the total divergence followed by branches per plant, plant height and days to maturity.

3.2 Diversity analysis

Cluster analysis divides an enormous amount of accessions into a few homogeneous clusters, rendering it easier to choose diverse accessions. The genotypes were grouped into five clusters based on non-hierarchical euclidean cluster analysis statistics as shown in Table 3 and Fig 3. The number of accessions fallen under cluster V was the highest (9) followed by cluster I (8), cluster IV (8), cluster III (3) and cluster II (2). The order of distribution of all genotyping into five clusters revealed the presence of significant genetic diversity among genotypes for the majority of the attributes under investigation. Some earlier researchers observed different clustering patterns in linseed (Kandil et al., 2011; Pali and Mehta, 2017; and Patial et al., 2019). The cluster mean of different quantitative characters for different clusters have been presented in Table 4. The maximum value for grain yield per plant was recorded in cluster I followed by cluster V, cluster III and cluster II. Cluster I had genotypes having higher mean values for characters like days to maturity, plant height, seeds per capsule, plant stand, yield per plant and also desirable for early flowering trait. Whereas, clusters V had high mean values for yield contributing traits *viz.*, capsule per plant, branches per plant and germination per cent. The genotypes in the preceding cluster may be targeted for numerous crossing programs in order to develop transgressive segregates with better yield.

Table 1: List of 30 linseed genotypes along with source used in the study.

1.	RL-15597	9.	RL-18113	17.	RL-18121	25.	RL-18102
2.	RL-18104	10.	RL-18114	18.	RL-18122	26.	RL-18103
3.	RL-18105	11.	RL-18115	19.	RL-18123	27.	PA-2
4.	RL-18106	12.	RL-18116	20.	RL-18124	28.	KBA-5
5.	RL-1007	13.	RL-18117	21.	RL-13165	29.	KBA-6
6.	RL-18110	14.	RL-18118	22.	RL-18109	30.	T-397
7.	RL-18111	15.	RL-18119	23.	RL-18107	Source- AICRP on Linseed and ARS, Kota	
8.	RL-18112	16.	RL-18120	24.	RL-18101		

Table 2:-Principal Component analysis (PCA) based on standard data for 11 quantitative traits of linseed.

Characters	PC1	PC2	PC3	PC4
Days to 50% flowering	-0.38	0.42	-0.03	0.13
Days to flowering	-0.31	0.45	0.09	0.20
Days to maturity	0.30	0.00	0.49	-0.22
Plant height	0.40	0.20	-0.03	-0.22
Capsule per plant	0.48	0.15	0.06	0.19
Seed per capsule	0.11	-0.09	-0.59	0.05
Plant stand	0.00	0.47	-0.12	-0.32
Test weight	0.15	-0.06	-0.04	0.79
Branches per plant	0.38	0.27	0.23	0.19
Germination per cent	0.14	0.47	-0.23	0.03
Yield per plant	0.25	-0.03	-0.49	-0.13
Eigen values	2.86	2.21	1.47	1.23
Percent variance	26.08	20.13	13.43	11.23
Cumulative Proportion	26.08	46.21	59.64	70.87

Table 3: Grouping of thirty genotypes of linseed into five clusters.

Cluster No.	Name of genotypes	Number of genotypes
I	RL-18101, RL-18107, RL-18124, PA-2, RL-1007, RL-18102, RL-13165, KBA-5	8
II	RL-18104, T-397	2
III	RL-18119, RL-18120, RL-18121	3
IV	RL-18103, RL-18110, RL-18116, RL-18117, RL-18113, RL-18105, RL-18114, RL-18115	8
V	RL-18118, RL-18123, RL-18106, KBA-6, RL-18109, RL-	9

	18112, RL-18122, RL-15597, RL-18111	
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Table 4: Mean values of different characters for thirty genotypes of linseed grouped in different clusters.

Cluster No	Character's Name										
	DFE	DF	DM	PH	CPP	SPC	PS	TW	BPP	GP	YPP
I	61.000	65.000	121.000	79.270	111.170	8.530	353.000	7.830	4.330	70.000	2.183
II	62.000	66.000	120.800	60.014	93.122	7.816	311.800	7.668	4.174	73.000	1.743
III	61.077	65.385	120.769	62.201	87.425	8.161	269.154	7.720	3.918	66.409	1.916
IV	60.750	65.000	120.750	60.785	92.325	8.165	205.250	7.975	4.035	60.000	1.619
V	60.143	65.000	122.143	70.280	113.014	8.303	271.571	7.870	4.409	73.333	2.151

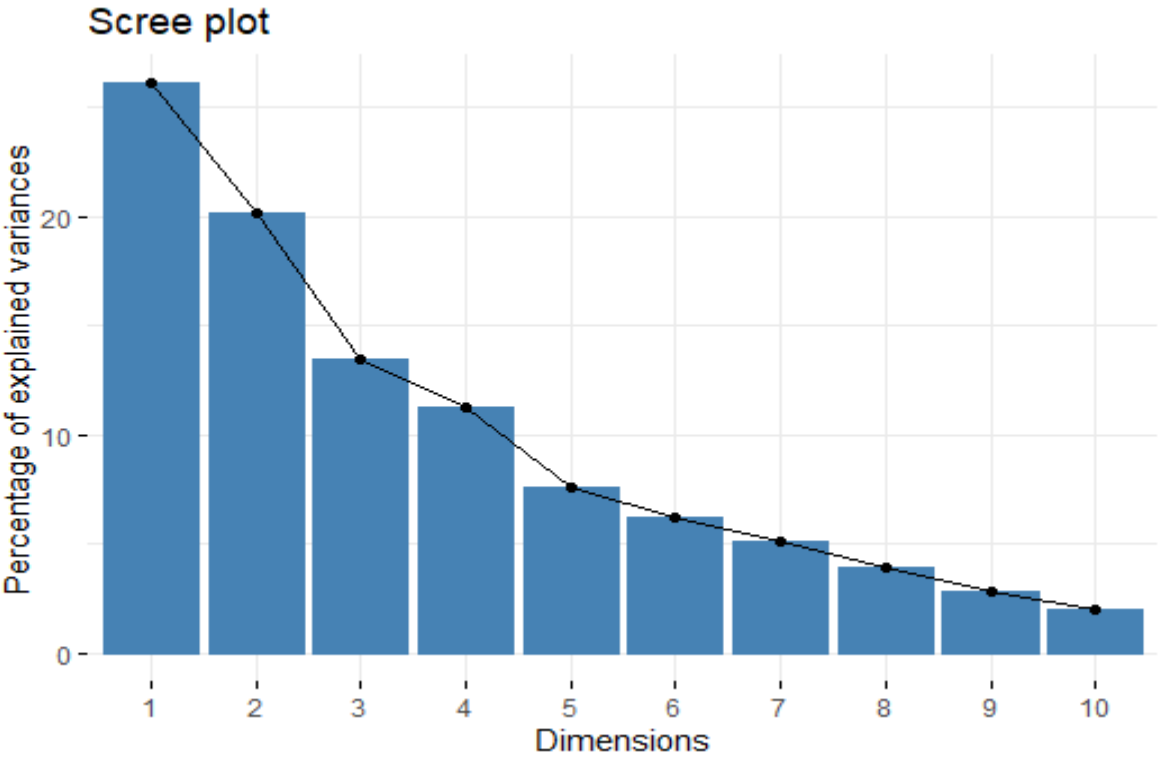


Figure 1: Scree plot for contribution of different principal components

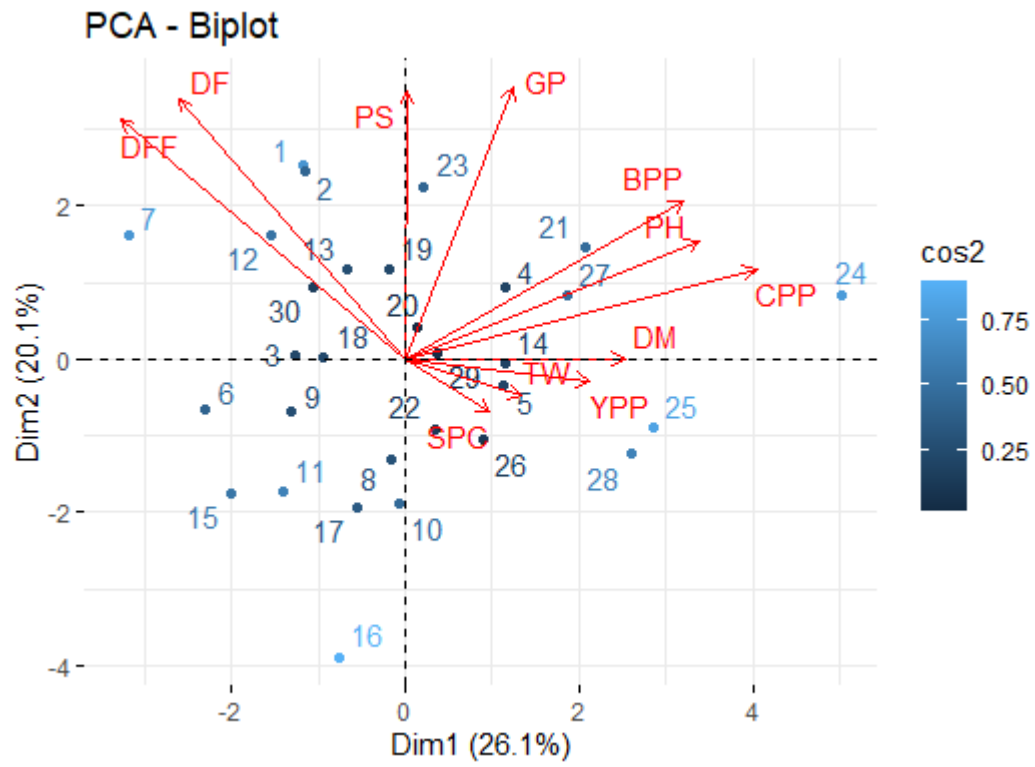


Figure 2: Biplot of 30 genotypes of linseed on principal component axis 1 and 2.

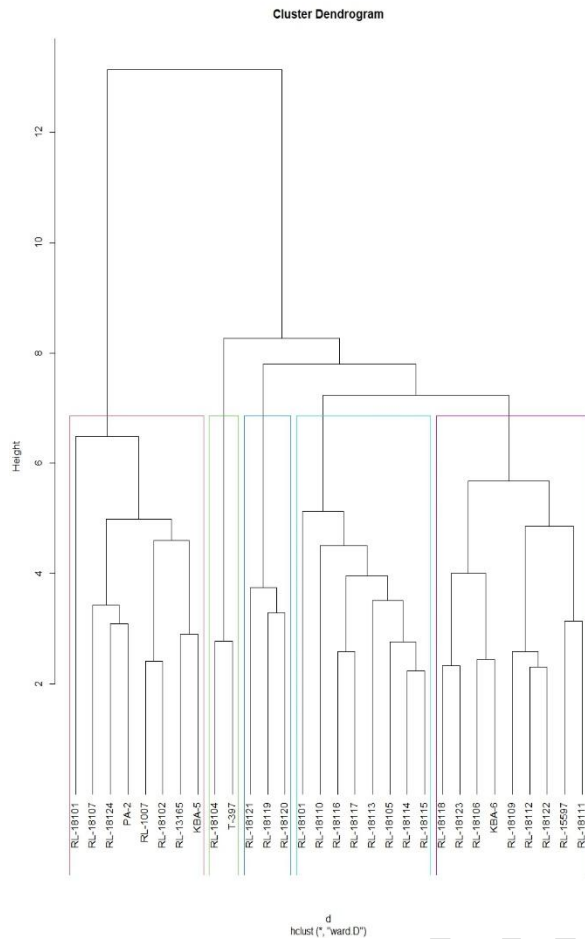


Figure 3:Dendrogram depicting relationships among the linseed genotype for different traits

4. CONCLUSION

Both multivariate methodologies revealed that the germplasm used in the study had extensive of genetic diversity. Four of the eleven principal components were significant (eigenvalue >1) and accounted for 70.87 per cent of the variance, according to PCA. The yield and its contributing characteristics dominated in PC1 and PC2. Therefore, by utilizing heterosis, choosing germplasm with high PC1 and PC2 scores may lead to higher yield and yield characteristics. To develop superior high yielding lines, high-performing material from each cluster can be used in a hybrid breeding program. As a result, breeders will profit substantially from the study's germplasm in terms of selecting prospective parental lines.

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