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# Principal component analysis of Niger germplasm

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**Abstract**
The present investigation was carried out at Project Coordinating Unit (Sesame and Niger) Research Farm, JNKVV, and Jabalpur (M.P.) during 2015-16 to determine the relationship and genetic diversity among 71 Niger germplasm accessions using principal component analysis. In this study, Principal component 1 had the contribution from the traits viz., number of secondary branches per plant, number of capitula per plant, 1000 seed weight, seed yield per plant and seed length which accounted 25.78% to the total variability. Number of primary branches per plant and free fatty acid content (%) has contributed 17.92% to the total variability in principal component 2. Days to 50% flowering and days to maturity has contributed 12.30% to the total variability in principal component 3. The remaining variability of 8.39% and 7.41% was consolidated in principal component 4 and principal component 5 by various traits like oil content and plant height. The cumulative variance of 71.82% of total variation among 11 characters was explained by the first five axes. Thus the results of principal component analysis revealed, wide genetic variability exists in this Niger germplasm accessions.

**Keywords:** principal component analysis, niger and germplasm

## Introduction

Niger (*Guizotia abyssinica* (L. f.) Cass.) being an oilseed crop is mainly cultivated in Indian subcontinent and East African Countries [5]. Niger though a native to Tropical Africa, is wide spread and extensively cultivated in India since long and constitutes about 50% of Ethiopian and 3% Indian oilseed production. In India, it is primarily grown on the degraded soils in hilly and tribal pockets under input starved conditions over an area of about 3 lakh ha with larger area in Chhattisgarh, MP, Maharashtra and Odisha. It can be grown successfully without chemicals. In MP, it is grown in 0.43 lakh ha area with production of 0.16 lakh tonnes and productivity of 372 kg /ha [1]. Niger seeds contain about 40% edible oil with fatty acid composition of 75-80% linoleic acid, 7-8% palmitic and steric acids, and 5-8% oleic acid [4]. However, keeping quality of Niger is poor due to high content of unsaturated fatty acids. The oil is used for culinary purposes, manufacturing paints, soft soaps and for lighting and lubrication. Moreover, consuming Niger seed oil is beneficial from public health point of view because it contains minor quantities of substances such as tocopherols, phospholipids and sterols that provide protection against cardiovascular disorders and cancer [10]. Niger seed cake is a valuable cattle feed, particularly for milch cattle. Niger meal with 30% protein and 17% crude fibre in India could replace linseed cake in calf ration. Niger is a completely out crossing species with self-incompatibility mechanism. Variability exists for morphological characters [9]; however these characters are not discrete and hence, complicate the Niger improvement programs. Consequently, varieties identification or genetic purity assessment are difficult. Development of improved plant cultivars is restricted mainly due to limited genetic variability. Due to narrow genetic pool it is not possible to restructure the Niger crop. Wide genetic diversity is very important in selecting the parents for hybridization programmes to identify herterotic crosses and obtain desirable recombination in the segregating generations [3]. The systemic management of plant genetic resources is very important to augment productivity of Niger. Principal Component Analysis (PCA) is a multivariate technique that analyses a data table in which observations are described by several inter-correlated quantitative dependent variables. Its goal is to extract the important information from the table, to represent it as a set of new orthogonal variables called principal components, and to display the pattern of similarity of the observations and of the variables as points in maps. 'Proper values' measure the importance and contribution of each component to total variance, whereas each coefficient of proper vectors indicates the degree of contribution of every original variable with which each principal component is associated. The higher the coefficients, regardless of the direction

(Positive or negative), the more effective they will be in discriminating between accessions. The study is aimed to determine level of germplasm variation in Niger to identify and classify variation for grouping the accessions by taking into account several characteristics and relationship between them.

## Materials and Methods

The present experiment was conducted under Project Coordinating Unit (Sesame and Niger) Research Farm, JNKVV, and Jabalpur (M.P.) during 2015-16. The soil of the experimental area is medium black with uniform topography and free from water logged conditions. Jabalpur has sub-tropical and semi-arid climate. The main features are hot and dry summer and cold winter with occasional showers. The minimum and maximum temperatures range between $22^0$C to $35^0$C, respectively during the *kharif* season. The experimental material consisted of 71 Niger germplasm (Table 1) laid out in a Randomized Block Design replicated thrice.

**Table 1:** Experimental material

| S. No. | Germplasm | S. No. | Germplasm | S. No. | Germplasm |
|---|---|---|---|---|---|
| 1 | 5-64 | 25 | IGP-76 | 49 | IGP-38 |
| 2 | 5-9 | 26 | NA-48 | 50 | RCR-64 |
| 3 | 5-1 | 27 | GA-23 | 51 | RCR-5-4 |
| 4 | 5-5 | 28 | DB-500 | 52 | IGP-50 |
| 5 | 5-4 | 29 | NO.36 | 53 | EC-158660 |
| 6 | 5-20 | 30 | IGP-37 | 54 | EC-158669 |
| 7 | 41-52 | 31 | M-3 | 55 | EC-158670 |
| 8 | 89-25 | 32 | IGP-234 | 56 | EC-158671 |
| 9 | 23-4 | 33 | PHULE-4 | 57 | EC-158672 |
| 10 | 89-20 | 34 | NO.1 | 58 | EC-158673 |
| 11 | 18-64 | 35 | COMP-II | 59 | NC-63586 |
| 12 | 5-70 | 36 | NO.14 | 60 | NC-62587 |
| 13 | 52-26 | 37 | COMB-2 | 61 | NC-63588 |
| 14 | 87-14 | 38 | CH-32 | 62 | NC-63591 |
| 15 | 41-50 | 39 | CH-4 | 63 | NC-63592 |
| 16 | 71-41 | 40 | KOMKEMP | 64 | NC-63595 |
| 17 | 87-32 | 41 | NR-76-14 | 65 | NC-63597 |
| 18 | 34-14 | 42 | MUTUNAY | 66 | N-20 |
| 19 | BHC-120 | 43 | BPB-1 | 67 | N-35 |
| 20 | GA-8 | 44 | GA-10 | 68 | CWA-1 |
| 21 | NO.5 | 45 | GOUDAGUDA | 69 | GA-5 |
| 22 | CH-53 | 46 | IGP-11 | 70 | NR-73-13 |
| 23 | CH-7 | 47 | GA-2 | 71 | IGPN-2004-1 (Check) |
| 24 | Gheta No.1 | 48 | PHULE-2 | | |

The distance between rows was maintained at 0.40 m and plant to plant 0.15 m. The crop was raised under recommended package of practices along with prophylactic protection measures. The observations were recorded on days to 50% flowering, days to maturity, plant height, number of primary branches/plant, number of secondary branches/plant, number of capitula/plant, 1000 seed weight, seed length, oil content (%), free fatty acid content (%) and seed yield/plant (g). The data on yield and quality traits were statistically analyzed on the basis of model described by [9] for randomized complete block design. The PCA analysis reduces the dimensions of a multivariate data to a few principal axes, generates an Eigen vector for each axis and produces component scores for the characters [7, 8].

## Results and Discussions

PCA is a well-known method of dimension reduction that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set [7, 8]. The result of the PCA explained the genetic diversity of the Niger germplasm collection. There are no standard tests to prove significance of proper values and the coefficients. Principal component analysis has shown the genetic diversity of the germplasm lines. The cumulative variance of 71.82% (Table 2) by the first five axes with Eigen value of > 0.5 indicates that the identified traits within the axes exhibited great influence on the phenotype of germplasm lines. A Scree plot explained the percentage of variance associated between Eigen values and principal components with each PC obtained by drawing a graph. First principal component recorded the highest variation 25.78% (PC1) followed by 17.92% (PC2), 12.30% (PC3), 8.399% (PC4) and 7.414% (PC5). Total variation of five PCs was recorded to be 71.824%. Semi curve line obtained after eigth PC with little variation observed in each PC indicated that maximum variation was found in PC1; therefore selection of lines for characters under PC1 may be desirable (Figure 1 and 2).

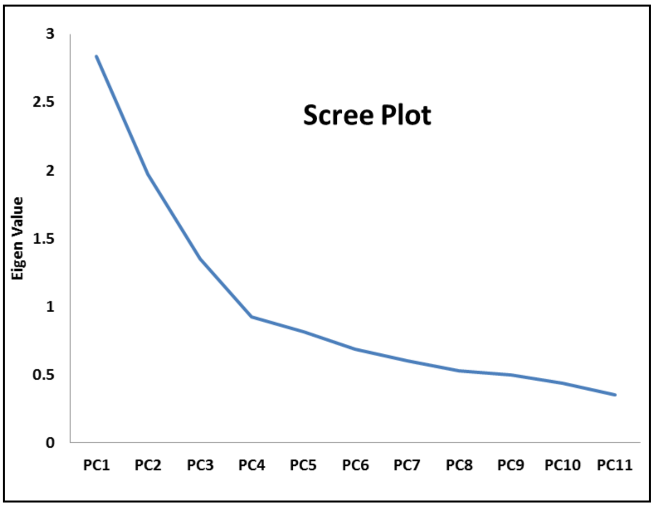


**Fig 1:** Scree plot of principal component analysis of Niger genotypes between Eigen value and principal component.

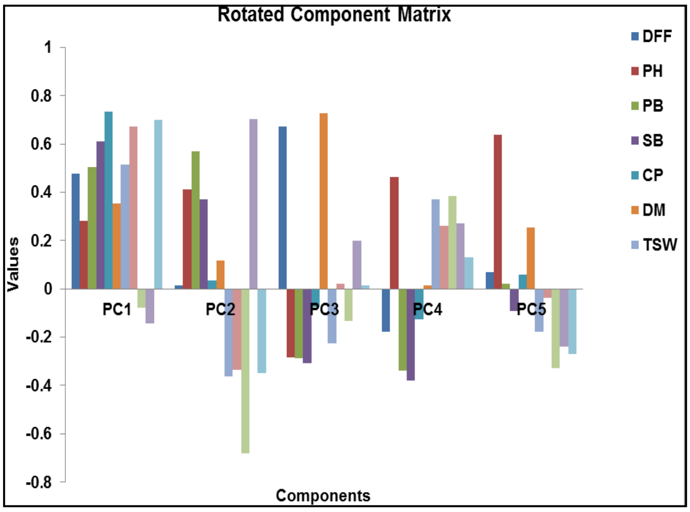


**Fig 2:** Rotated component matrix

**Table 2:** Eigen values, % variance and cumulative Eigen values of Niger germplasm

| Characters | Principal component (PC) | Eigen value | Variability (%) | Cumulative % |
|---|---|---|---|---|
| DFF | PC1 | 2.837 | 25.788 | 25.788 |
| PH | PC2 | 1.971 | 17.921 | 43.709 |
| PB | PC3 | 1.353 | 12.302 | 56.011 |
| SB | PC4 | 0.924 | 8.399 | 64.410 |
| CP | PC5 | 0.816 | 7.414 | 71.824 |
| DM | PC6 | 0.686 | 6.233 | 78.057 |
| TSW | PC7 | 0.601 | 5.459 | 83.516 |
| SL | PC8 | 0.529 | 4.813 | 88.329 |
| Oil % | PC9 | 0.498 | 4.524 | 92.853 |
| FFA % | PC10 | 0.435 | 3.953 | 96.806 |
| SY/P | PC11 | 0.351 | 3.194 | 100.000 |

Rotated component matrix revealed that first five PCs are representing maximum variability (71.824%) hence, the traits falling in these five PCs may be given due importance in Niger breeding. It revealed that the first principal component (PC1) which accounted for the highest variation (25.78%) was mostly related with yield traits such as number of secondary branches per plant, number of capitula per plant, 1000 seed weight, seed yield per plant and seed length. Thus, PC1 allows for simultaneous selection of yield related traits and can be regarded as yield factor. The second principal component (PC2) was dominated by yield and quality related traits *viz*., number of primary branches per plant and free fatty acid content (%), while PC3 consisted of mainly phenological traits *viz*., days to 50% flowering and days to maturity. Fourth principal component was related with oil content (%) and fifth principal component with plant height (Table 3). On the basis of PCA, most of the important yield attributing and quality traits were present in PC1, PC2 and PC4. Similar results were reported by [6] for seed yield per plant and days to maturity; [2] for seed yield per plant in soybean.

**Table 3:** Principal components for 11 yield contributing traits of Niger

| Traits | Principal Components | | | | |
|---|---|---|---|---|---|
| | PC1 | PC2 | PC3 | PC4 | PC5 |
| DFF | 0.478 | 0.015 | 0.673 | -0.179 | 0.070 |
| PH | 0.283 | 0.411 | -0.285 | 0.465 | 0.638 |
| PB | 0.505 | 0.569 | -0.287 | -0.338 | 0.020 |
| SB | 0.612 | 0.370 | -0.307 | -0.378 | -0.090 |
| CP | 0.735 | 0.036 | -0.074 | -0.125 | 0.059 |
| DM | 0.355 | 0.117 | 0.727 | 0.014 | 0.253 |
| TSW | 0.514 | -0.364 | -0.225 | 0.370 | -0.176 |
| SL | 0.674 | -0.335 | 0.020 | 0.260 | -0.036 |
| oil % | -0.078 | -0.680 | -0.134 | 0.385 | -0.328 |
| FFA % | -0.144 | 0.705 | 0.198 | 0.271 | -0.238 |
| SY/P | 0.699 | -0.349 | 0.013 | 0.130 | -0.271 |

## PC scores of genotypes

The PC scores of the each component (PC1, PC2, PC3, PC4 and PC5) had positive and negative values (Table 3). These scores can be utilized to propose precise selection indices whose intensity can be decided by variability explained by each of principal component. High PC score for a particular genotype in a particular component denotes high values for the variables in that particular genotype. In PC1, the positive scores ranged from 5.308 (GOUDAGUDA) to 0.646 (MUTUNAY), while negative value ranged from -3.0483 (NR-76-14) to -0.515 (IGP-37). In PC2, the positive value of the component ranged from 4.647 (DB-500) to 0.511 (5-1) and negative value ranged from -2.493 (EC-158673) to -0.681(NC-62587). In PC3, the positive value of the components ranged from 2.746 (41-50) to 0.595 (BPB-1) and negative from -1.999 (CWA-1) to -0.559 (COMB-2). In PC4, the positive value of the components ranged from 3.557 (5-4) to 0.611 (41-52), while negative value ranged from -1.652 (IGP-234) to -0.518 (NC-63595). In PC5, the positive value of the components ranged from 1.978 (5-1) to 0.553 (EC-158669), while negative value ranged from -2.665 (IGPN-2004-1) to 0.517 (87-14). The PC scores of the each component (PC1, PC2, PC3, PC4 and PC5) had positive and negative values. Germplasm lines showing maximum positive PC scores and common in PC1, PC2 and PC4 which are mostly related with yield and quality traits are PHULE-4, CH-7, 5-1, BPB-1, NO.14, NO.36, EC158669, GA-5, GOUDAGOUDA, NO-1, IGP-76, IGP-37, DB-500, 41-52 and EC 158671. Maximum negative values were recorded in NC-63592, CH-32, IGP-234, NO.5, EC-158673, COMP-II, 5-4, RCR-64, NC-63595 and COMB-2 germplasm lines for traits days to 50% flowering, days to maturity and free fatty acid content (%).

An intensive selection procedures can be designed to bring about rapid improvement of dependent traits i.e., yield and quality traits in Niger by selecting lines from PC1, PC2 and PC4. Thus, selection of these lines can help in further development of new high yielding and good quality varieties of Niger.

## Conclusion

The phenotypic value of the each trait measures the importance and contribution of each component to total variance, whereas each coefficient of proper vectors indicates the degree of contribution of every original variable with which each principal component is associated. Thus, the prominent characters coming together in different principal components and contributing towards explaining the variability and have the tendency to remain together this may be kept into consideration during utilization of these characters in breeding program.

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## Author contributions

The research work is a M.Sc (Ag) thesis work and both the author and co-author have contributed equally to the analytical methods used for the research concept and the experiment design.

## Abbreviations

DFF: Days to 50% flowering, PH: Plant height, PB: No. of primary branches/plant, SB: No. of secondary branches/plant, CP: No. of capitula/plant, DM: Days to maturity, TSW: 1000 seed weight, SL: Seed length (cm), FFA %: Free fatty acid (%), SY/P: Seed yield/plant.

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