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Principal component analysis of niger genotypes

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Abstract
The current research was carried out at Project Coordinating Unit (Sesame and Niger) Research Farm, JNKVV, Jabalpur (M.P.) during *kharif* 2021 for the assessment of genetic diversity among 84 genotypes of niger using principal component analysis. In this investigation, Principal component 1 had the contribution from the characters *viz*., number of seeds per capitulum, harvest index and seed yield per plant contributing 37.46% to the total variability. Days to flower initiation and days to 50% flowering contributed 17.32% to the total variability in principal component 2. Plant height had contributed 11.35% to the total variability in principal component 3. Days to maturity and diameter of capitula contributed 8.33% to the total variability in principal component 4. The cumulative variance of 74.46% of total variability was observed among 12 characters was explained by first four axes. The result of principal component analysis revealed that Goudaguda, AJSR-45, AJSR-35, IC-210956, AJSR-24, AJSR-29, AJSR-25, AJSR-49, AJSR-43, IC-210948, AJSR-28, IC-210947, JNS-30 (C), IC-210925, AJSR-36 and AJSR-61 were potential lines. Therefore, these lines should be utilized for further breeding program to achieve trait specific desirable varieties of niger with wider adaptivity.

Keywords: Principal component analysis, niger, genotypes

Introduction
Niger (*Guizotia abyssinica*) belonging to family Asteraceae is minor oilseed crop with its centre of diversity and origin in Ethiopia. Niger constitutes about 3% of Indian and 50% of Ethiopian oilseed production in world. Niger is self incompatible crop with chromosome number of 2n=2x=30 (Bisen *et al.,* 2016) [3]. The crop is grown mainly for its oil and seed. The niger seed contains about 35 to 40% oil with fatty acid composition of linoleic acid 75 to 80%, palmitic and stearic acids 7 to 8% and oleic acid 5 to 8%. The oil of niger seed is used to prepare different types of dietary foods, paints, soaps, and as an illuminant. Niger can be easily processed to replace partial or full petroleum based diesel fuel as an alternate resort of bio-fuel (Sarin *et al*., 2009) [9]. The quantum of genetic variability present in the population determines the breeding strategy for improvement in any crop species. In addition to the genetic variability, knowledge on heritability and genetic advance helps the breeder to employ the suitable breeding strategy. The correlation studies simply measure the associations between yield and other traits whereas, the path analysis permits the understanding of cause and effect of related characters (Suryanarayan *et al*., 2018) [10]. The breeding for high seed yield in niger is the need of hour, which can facilitate the development of high seed and oil yielding varieties to fulfil the growing demands of oil. However, the narrow genetic base of improved niger cultivars has been a limitation. To alleviate this, parents with broad genetic base will be required in the breeding programmes. There are some studies on genetic diversity for seed yield and morphological traits in germplasm of this crop, indicating significant genetic diversity for morphological, agronomical as well as biochemical traits (Ahirwar *et al.,* 2017) [1]. Principal component analysis is a statistical tool which helps determine the amount of the genetic diversity among the germplasm; and importance and contribution of each contributing traits to the total variance. The first principal component accounts for as much variability possible in data and each succeeding component accounts for as much of remaining variability possible in data. Each succeeding component is in turn uncorrelated to preceding component. This study was aimed to determine the genetic diversity among the niger genotypes and identify traits contributing to the total variability, for their exploitation in the future niger breeding programme.

Materials and Methods

The research work was carried out at the Project Coordinating Unit (Sesame and Niger) Research Farm, JNKVV, Jabalpur (M.P) during *Kharif* 2021. The experimental materials consisted of 84 niger accessions *i.e.*, 81 germplasm accessions of niger (56 AJSR coded locally collected material Jabalpur, one named germplasm Goudaguda and 24 local germplasm with IC number from NBPGR) along with 3 checks namely Jawahar niger selection (JNS-9, JNS-28 and JNS-30) procured from PC Unit (Sesame and Niger) Jabalpur. The germplasm aaccessions used as experimental material are listed in Table1.

Table 1: List of niger germplasm accessions used as experimental material during *kharif* 2021

S. No.	Germplasm	S. No.	Germplasm	S. No.	Germplasm
1	AJSR-24	9	AJSR-31	17	AJSR-39
2	AJSR-25	10	AJSR-32	18	AJSR-4
3	AJSR-26	11	AJSR-33	19	AJSR-40
4	AJSR-27	12	AJSR-34	20	AJSR-41
5	AJSR-28	13	AJSR-35	21	AJSR-42
6	AJSR-29	14	AJSR-36	22	AJSR-43
7	AJSR-3	15	AJSR-37	23	AJSR-44
8	AJSR-30	16	AJSR-38	24	AJSR-45
25	AJSR-46	45	AJSR-64	65	IC-210933
26	AJSR-47	46	AJSR-65	66	IC-210939
27	AJSR-48	47	AJSR-66	67	IC-210941
28	AJSR-49	48	AJSR-67	68	IC-210942
29	AJSR-5	49	AJSR-68	69	IC-210945
30	AJSR-50	50	AJSR-69	70	IC-210946
31	AJSR-51	51	AJSR-7	71	IC-210947
32	AJSR-52	52	AJSR-70	72	IC-210948
33	AJSR-53	53	AJSR-71	73	IC-210950
34	AJSR-54	54	AJSR-72	74	IC-210951
35	AJSR-55	55	AJSR-73	75	IC-210952
36	AJSR-56	56	AJSR-74	76	IC-210953
37	AJSR-57	57	Goudaguda	77	IC-210954
38	AJSR-58	58	IC-210918	78	IC-210956
39	AJSR-59	59	IC-210919	79	IC-210957
40	AJSR-6	60	IC-210920	80	IC-210967
41	AJSR-60	61	IC-210923	81	IC-210941
42	AJSR-61	62	IC-210925	82	JNS-9 (Check)
43	AJSR-62	63	IC-210928	83	JNS-28 (Check)
44	AJSR-63	64	IC-210932	84	JNS-30 (Check)

The row x row spacing was 30 cm and plant x plant spacing was 10 cm. Normal recommended doses of fertilizers, *i.e.*, 30kg N: 20kg P_2O_5: 10kg K_2O were used. Nitrogen was administered in two split doses, 10kg ha^{-1} at time of sowing as basal dose and remaining 20kg N ha^{-1} 30 days after sowing. While P and K were administered as basal doses during field preparation. Observations were taken by selecting 5 plants randomly from each genotype for different characters *viz.*, days to flower initiation, days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of capitula per plant, diameter of capitula (cm), number of seeds per capitulum, 1000 seed weight (g), seed yield per plant (g), seed oil content (%) and harvest index (%). The observations recorded were subjected to Principal Component Analysis (PCA).

Result and Discussion

The results of the PCA analysis based on the observations recorded are presented in the table 2. Out of twelve, only four principal components (PCs) exhibited more than 1.00 and were selected as suggested by Jeffers (1967) [5]. Eigen value and showed about 74.46% variability among the traits studied. Hence these four principal components were given importance for further explanation. The PC1 had the highest variability (37.46%) followed by PC2 (17.32%), PC3 (11.35%) and PC4 (8.33%) for traits under study.

Table 2: Eigen values, percentage of total variation and cumulative percentage for corresponding twelve traits in niger genotypes

Characters	Principal component	Eigen values	Variability (%)	Cumulative (%)
DFI	PC1	4.50	37.46	37.46
DFF	PC2	2.08	17.32	54.78
DM	PC3	1.36	11.35	66.13
PH	PC4	1.00	8.33	74.46
NBPP	PC5	0.85	7.05	81.51
NCPP	PC6	0.64	5.03	86.81
CD	PC7	0.59	4.94	91.75
NSPC	PC8	0.51	4.29	96.04
SOC	PC9	0.25	2.10	98.14
HI	PC10	0.15	1.26	99.4
1000 SW	PC11	0.05	0.45	99.85
SYPP	PC12	0.02	0.14	99.99

Where, DFI= days to flower initiation; DFF= days to 50% flowering; DM= days to maturity; PH= plant height (cm), NBPP= number of branches per plant; NCPP= number of capitula per plant; CD= diameter of capitula (cm); NSPC= number of seeds per capitulum; SOC= seed oil content (%); HI= harvest index (%); 1000 SW= 1000 seed weight (g); SYPP= seed yield per plant (g).

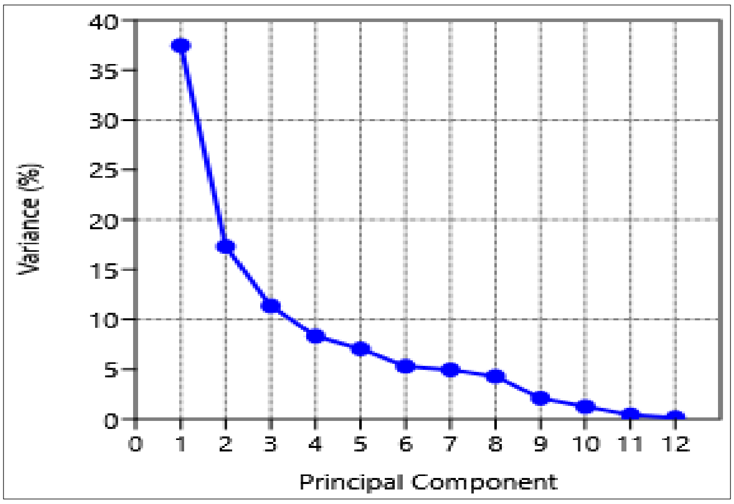

Fig 1: Scree plot based on percentage variability of the principal components

Scree plot laid out using percentage variability of the principal component (Fig. 1) formed a semi curve line. PC1 showed highest variability (37.46%) with Eigen value 4.50 which then declined gradually. Also obtained highest variability in PC1 with Eigen value more than 1.0. The semi curve line obtained in the scree plot tend to become straight after fourth PC with little variation observed in each PC. From the graph it is clear that the highest variability was observed in PC1; therefore, selection of germplasm lines of PC1 may be desirable. The principal components having Eigen value more than 1.00 showed more variation among the niger germplasm and therefore lines from these principal components can be used for selection of the diverse parents to be included in the crop improvement programs.

Table 3: Rotated component matrix for twelve yield contributing traits of Niger genotypes

Character	PC1	PC2	PC3	PC4
DFI	0.177	0.604	-0.113	-0.174
DFF	0.195	0.594	-0.114	-0.179
DM	0.146	0.369	0.062	0.518
PH	0.185	-0.131	0.565	-0.238
NBPP	0.326	-0.029	0.249	-0.043
NCPP	0.378	-0.104	0.222	-0.097
CD	-0.108	0.116	0.420	0.693
NSPC	0.520	-0.089	-0.081	0.027
SOC	-0.030	-0.169	-0.528	0.244
HI	0.508	-0.122	-0.150	0.188
1000 SW	0.294	-0.197	-0.199	0.121
SYPP	0.528	-0.119	-0.127	0.103

Extraction method: Principal Component Analysis
Note: A bold value represents more related traits in each principal component.

Table 4: Interpretation of rotated component matrix for traits having maximum values ≥ 0.5 in each PCs

	PC1	PC2	PC3	PC4
Traits	NSPC	DFI	PH	DM
	HI	DFF		CD
	SYPP			

In 84 genotypes of niger, the top principal component scores (PC score) for all traits were estimated for these four components and presented in table 3 and table 4. The scores can be used to propose precise selection indices whose intensity can be decided by the variability explained by each principal component. High PC scores for a particular genotype in a particular component indicate high values for the variable in that particular genotype. Rotated component matrix revealed that PC1 followed by PC3 accounted for yield and yield contributing traits *i.e*., number of seeds per capitulum, harvest index (%), 1000 seed weight (g) and seed yield per plant (g). Goudaguda had the highest PC score (Table 5) followed by AJSR-45, AJSR-35, IC-210956, IC-210918, AJSR-24, AJSR-3, AJSR-29, IC-210952, AJSR-25, AJSR-49, AJSR-43, IC-210948, IC-210951, AJSR-28, IC210957, IC-21094, JNS-30, AJSR-53, IC-210923, IC-210942, AJSR-44 and IC-210950 in PC1 suggesting that these genotypes possess high values of traits *viz.*, number of seeds per capitulum, harvest index and seed yield per plant. The highest PC score was obtained for AJSR-26 followed by AJSR-29, AJSR-3, AJSR-74, JNS-30, AJSR-27, AJSR-25, JNS-28, AJSR-28, JNS-9, AJSR, 24, AJSR-36 and AJSR-61 in PC2 was mainly related with days to flower initiation and days to 50% flowering. The highest PC score was obtained by AJSR-68 followed by AJSR-4, IC-210956, IC-210948, IC-210939, IC-210947, IC-210919, AJSR-7, AJSR-67, Goudaguda, IC-210932, AJSR-65, AJSR-61, IC-210925, AJSR-36, AJSR-33, AJSR-64 and AJSR-62 in PC3 was mainly related with Plant height (cm). PC scores in PC4 were recorded highest value for characters days to maturity and diameter of capitula by genotypes AJSR-49, AJSR-41, AJSR-73, AJSR-47, AJSR-42, AJSR-35, IC-210928, AJSR-38, AJSR-48, AJSR-28, IC-210925 and AJSR-39. Similar results were obtained by Khutney and Kumar (2015) [6], Kumar and Bisen (2019) [7].

Table 5: List of selected genotypes in each principal component

S. No.	PC1	PC2	PC3	PC4
1	Goudaguda	AJSR-26	AJSR-68	AJSR-49
2	AJSR-45	AJSR-29	AJSR-4	AJSR-41
3	AJSR-35	AJSR-3	IC-210956	AJSR-43
4	IC-210956	AJSR-74	IC-210948	AJSR-47
5	IC-210918	JNS-30	IC-210939	AJSR-42
6	AJSR-24	AJSR-27	IC-210947	AJSR-35
7	AJSR-3	AJSR-25	IC-210919	IC-210928
8	AJSR-29	JNS-28	AJSR-7	AJSR-38
9	IC-210952	AJSR-28	AJSR-67	AJSR-48
10	AJSR-25	JNS-9	Goudaguda	AJSR-28
11	AJSR-49	AJSR-24	IC-210932	IC-210925
12	AJSR-43	AJSR-36	AJSR-65	AJSR-39
13	IC-210948	AJSR-61	AJSR-61	-
14	IC-210951	-	IC-210925	-
15	AJSR-28	-	AJSR-36	-
16	IC-210957	-	AJSR-33	-
17	IC-210947	-	AJSR-64	-
18	JNS-30	-	AJSR-62	-
19	AJSR-53	-	-	-
20	IC-210923	-	-	-
21	IC-210942	-	-	-
22	AJSR-44	-	-	-
23	IC-210950	-	-	-

Conclusion
On the basis of present investigation we identified Goudaguda, AJSR-45, AJSR-35, IC-210956, AJSR-24, AJSR-29, AJSR-25, AJSR-49, AJSR-43, IC-210948, AJSR-28, IC-210947, JNS-30 (C), IC-210925, AJSR-36 and AJSR-61 with desirable characters *viz.*, number of seeds per capitulum, harvest index (%), seed yield per plant (g), days to flower initiation, days to 50% flowering, plant height (cm), days to maturity and diameter of capitula (cm), which used as parents in future hybridization programmes or direct selection for the development of new improved niger varieties.

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