International Journal of Agriculture and Food Science 2026; 8(7): 124-129

ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(7): 124-129
www.agriculturaljournals.com
Received: 20-04-2026
Accepted: 22-05-2026

Rasal PP
M.Sc. Scholar, Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Jambhale VM
Assistant Professor, Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Amolic VL
Senior Sorghum Breeder, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Damse DN
Assistant Professor, Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Patil MR
Associate Professor, Department of Agricultural Statistics, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Corresponding Author:
Rasal PP
M.Sc. Scholar, Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Assessment of genetic variability and diversity in Niger (*Guizotia abyssinica* (L.f.) *Cass*)

Rasal PP, Jambhale VM, Amolic VL, Damse DN and Patil MR

DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i7b.1691

Abstract
The investigation on "Genetic diversity studies in niger (*Guizotia abyssinica (L.f.) Cass*)" was conducted on 35 genotypes of niger to know the variability, interrelationship among yield and its components, their direct and indirect effects on seed yield and genetic divergence of various niger genotypes.The present investigation was undertaken during the Kharif, 2025 season to assess the genetic variability, heritability, genetic advance, and genetic divergence among thirty-five niger (*Guizotia abyssinica* (L.f.) Cass.) genotypes with the objective of identifying promising parents for future breeding programmes. The experiment was laid out in a Randomized Block Design with two replications, and observations were recorded on ten quantitative traits, including days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of internodes per plant, number of capitula per plant, number of seeds per capitulum, 1000-seed weight, seed yield per plant, and oil content.

Analysis of variance revealed significant differences among the genotypes for all traits except number of branches per plant and number of internodes per plant, indicating the existence of substantial genetic variability. High heritability coupled with high genetic advance as per cent of mean was observed for number of branches per plant, number of internodes per plant, and days to 50 per cent flowering, suggesting the predominance of additive gene action and the effectiveness of selection for these traits. Mahalanobis D^2 analysis grouped the genotypes into eight distinct clusters, indicating considerable genetic divergence. Plant height contributed the highest proportion to total genetic divergence, followed by seed yield per plant and number of capitula per plant. Among the genotypes evaluated, IGPN-1408, IGPN-1801, IGPN-1810, and IGPN-1932 exhibited desirable performance for important yield-related traits and may be effectively utilized as parents in hybridization programmes aimed at improving seed yield and related traits in niger.

Keywords: Genetic diversity, niger and D^2 values, GCV & PCV effects, Genetic Advance

Introduction
Niger (*Guizotia abyssinica* (L.f.) Cass.) is an important minor oilseed crop belonging to the family Asteraceae. It is a highly cross-pollinated annual diploid species (2n = 2x = 30) cultivated primarily for its seeds and oil. Although the crop originated in the Ethiopian highlands of tropical Africa, India is recognized as its secondary centre of diversity and has become the world's largest producer and exporter of niger seed. At present, niger is cultivated over an area of approximately 85,000 ha in India, with an annual production of 28,000 metric tonnes and an average productivity of 329 kg ha^{-1}. In Maharashtra, the crop occupies about 3.94 thousand ha with a production of 1,100 metric tonnes and an average productivity of 279 kg ha^{-1}, which is lower than the national average. Indian niger seed is exported mainly to the United States, the Netherlands, Italy, Germany, Belgium and Spain, and its export value has increased remarkably from ₹12 crore during 1990–91 to ₹281.95 crore during 2023–24, reflecting its growing economic importance.

Niger seeds contain 32–40% oil, characterized by a high proportion of unsaturated fatty acids. The oil contains approximately 75–80% linoleic acid, 5–8% oleic acid, and 7–8% palmitic and stearic acids, while Indian genotypes generally possess about 55% linoleic acid and 25% oleic acid. The seeds contain approximately 19.4% protein, 0.05% calcium and 0.18% phosphorus, whereas the defatted meal contains about 30% protein and 23% crude fibre, making it a valuable livestock feed. The high linoleic acid content, along with naturally occurring tocopherols and sterols, enhances the nutritional quality of niger oil and contributes to its health-promoting properties, including protection against cardiovascular diseases. The oil is also utilized in food, cosmetic and paint industries, while the absence of pesticide residues further enhances its export potential. Despite its nutritional, industrial and economic significance, niger has remained a neglected oilseed crop with limited systematic breeding efforts. Low productivity is mainly attributed to cultivation under rainfed and marginal environments, the use of traditional low-yielding cultivars, protandrous self-incompatibility, poor seed set, dependence on insect-mediated cross-pollination, and susceptibility to various biotic stresses. Consequently, the available genetic variability has not been adequately exploited for crop improvement. Comprehensive evaluation of germplasm for genetic variability, genetic diversity, heritability and associated yield-contributing traits is therefore essential for identifying superior genotypes and developing efficient breeding strategies. The present investigation was undertaken to assess the genetic potential of diverse niger genotypes and generate information useful for the selection of promising parents and the development of high-yielding cultivars with improved agronomic performance and enhanced seed yield.

Material and Methods

The investigation of 35 genotypes which were obtained from the ZARS, Igatpuri, Nashik. The experiment was evaluated in a Randomized Block Design (RBD) with two replications each genotype was sown in single row of 4.5 m length with spacing 30 cm between row and 15 cm within rows. The observations were recorded on five randomly selected plants from each treatment in each replication for ten morphological characters *viz*., days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of internodes per plant, number of capitula per plant, number of seeds per capitulum, 1000-seed weight, seed yield per plant, and oil content.

Analysis of variance commonly applicable to the Randomized Block Design (Panse and Sukhatme, 1995) [25].

The analysis of divergence was carried out by D^2 statistics proposed by Mahalanobis (1936) as described by Rao (1952) [33].

Results and Discussion

Analysis of Variances

The analysis of variance revealed highly significant differences for all the characters studied except for number of branches per plant and internodes per plant (Table 1). In plant breeding programme, wide range of variation among the genotypes paves the way to bring in desirable improvement in the crop. The present material therefore, could serve a pool for selection of suitable material in the breeding programme. Similar results were also reported by Patil (2000) [30], Kenjale *et al.* (2003) [16], and Sreedhar (2003) [38].

Genetic variability parameters

Parameters of genetic variability were recorded on ten quantitative traits *viz*., days to 50% flowering, days to maturity, plant height, number of branches per plant, number of internodes per plant, number of capitula per plant, number of seeds per capitula, 1000 seed weight, seed yield per plant and oil content.

Genotypic and Phenotypic Coefficients of Variation

Estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were classified as suggested by Sivasubramanian and Madhavamenon (1973) and are presented in Table 2. The characters of Number of branches per plant recorded high estimates of GCV (21.83%). Moderate GCV were observed for Days to 50 per cent flowering (10.59%), Seed yield per plant (12.39), 1000 seed weight (15.27%), Number of internodes per plant (18.06%). While Low GCV were observed for Oil content (%) (4.99%)

High estimates of PCV were observed for Number of branches per plant (22.29), followed by 1000 seed weight (20.49). Medium estimates of PCV were observed for Days to 50 per cent flowering (10.59), Seed yield per plant (17.81), Number of internodes per plant (18.99). While, low estimates of PCV were observed for Oil content (%) (5.37)

This was in conformity with the results of Ahmad *et al.* (2003) [1], Sreedhar (2003) [38], Patil and Duhoon (2005) [31], Panda and Sial (2012) [34], Ahmad *et al* (2016) [2], Dudhe *et al*. (2017) [11], Kusumlata *et al* (2018), Fekadu (2020) [12], Gururaja *et al*. (2021) [14], Bhoite *et al*. (2023) [6] and Baghel *et al* (2018) [4].

.

Heritability

Estimates of heritability in broad sense is presented in Table 2. The high estimates of heritability in broad sense were observed for Plant height (98.60%) followed by Number of capitula per plant (98.10%), Days to 50 per cent flowering (97.20%), Days to maturity (96.50%), Number of branches per plant (95.90%) and Number of seeds/capitula (94.70%), Number of internodes per plant (90.40%), Oil content (%) (86.60%). Whereas low estimates of heritability were observed for Seed yield per plant (48.40%), and 1000 seed weight (55.5%). While high heritability coupled with high genetic advance as % of mean was observed for Days to 50% flowering, number of branches per plant, number of internodes per plant, indicating the predominant role of additive gene action in the inheritance of these characters. These results are in conformity with results of Mathur and Gupta (1993) [20], Borole and Patil (1997) [8], Patil (2000) [30], Kenjale e*t. al.* (2003) [16], Sreedhar (2003) [38], Ahmad *et. al*. (2003) [1] and Patil and Duhoon (2005) [31], Patil *et al.* (2013) [28], Ekhlaque *et al*. (2016), Bamrotiya *et al*. (2016) [5], Kumar and Bisen (2016) [17], Valli *et al*. (2016) [42], Teja *et al*. (2024) [18].

Genetic advance

Genetic advance (at 5% selection intensity) was calculated by the formula cited by Allard (1960) [3]. The range of genetic advance observed from 0.64 to 25.31. The highest estimate of GA for Plant height was 25.31, followed by number of capitula per plant (20.33). Days to 50 per cent flowering (14.89) and Days to maturity (14.83) shows medium genetic advance. While Number of seeds per capitula (5.79), Number of branches per plant (5.65), Number of internodes per plant (4.16), Oil content (%) (3.77), 1000 seed weight (0.78), and Seed yield per plant (0.64) shows low estimates of genetic advance.

The range of genetic advance as a percent of mean is classified as suggested Johanson, *et al.* (1955a). High estimates of genetic advance as per cent of mean (Table 2) was observed for Number of branches per plant (44.03%) followed by Number of internodes per plant (35.38%), 1000 seed weight (23.45%), Days to 50 per cent flowering (21.21%).The medium estimates of genetic advance as per percent of mean was observed for Number of seeds per capitula (19.43%), Number of capitula per plant (18.04%), Seed yield per plant (17.77%), plant height (15.08%), days to maturity (14.70%) and Low estimates of genetic advance as percent of mean were observed for Oil content (%) (9.57%).

Considering the estimates of genotypic coefficient of variation, heritability, and genetic advance as per cent of mean together, it is evident that days to 50 per cent flowering, number of branches per plant, and number of internodes per plant are the most important traits. Therefore, hybridization followed by selection in the early generations for these characters would be an effective approach for their genetic improvement in niger.

Genetic divergence

The Mahalanobis D^2 statistics are computed for all possible pair of thirty five genotypes in order to assess the genetic diversity present among the genotypes under study. The clustering pattern based on magnitude of D^2 values was made and are presented in Table 5. The thirty-five genotypes are grouped into eight clusters. It reveals from Table 3 that cluster II had maximum eight genotypes followed by cluster I and III seven genotypes. The cluster VI have five genotypes followed by cluster IV and VII with three genotypes. The cluster V, VIII were solitary since they had only one genotype. Similar findings, where two of the five clusters were mono-genotypic, were reported by Aboye B.M. (2021).

The average inter and intra-cluster D^2 distances are presented in Table 4. The inter-cluster distance ranged from 28.62 to 216.34. The maximum inter-cluster distance was observed between clusters I and V (D^2 = 216.34), followed by clusters I and IV (D^2 = 199.77) and clusters III and V (D^2 = 187.61). In contrast, the minimum inter-cluster distance was recorded between clusters IV and V (D^2 = 28.62), followed by clusters VI and VIII (D^2 = 38.02) and clusters II and III (D^2 = 41.87).The intra-cluster distance ranged from 0.00 to 24.00. Among all the clusters, cluster VI exhibited the highest intra-cluster distance (D^2 = 24.00), followed by cluster IV (D^2 = 21.55) and cluster VII (D^2 = 17.72).

The cluster means for all ten characters are presented in Table 5. Considerable inter-cluster variation was observed for days to 50 per cent flowering, days to maturity, plant height, number of branches per plant, number of capitula per plant, number of internodes per plant, number of seeds per capitula, seed yield per plant, 1000 seed weight, and oil content.

The cluster mean for days to 50 per cent flowering ranged from 56.20 (cluster V) to 78.77 (cluster I). Similarly, the cluster mean for days to maturity varied from 87.44 (cluster V) to 109.71 (cluster I). The cluster mean for plant height ranged from 159.91 cm (cluster III) to 198.96 cm (cluster V), while the cluster mean for number of branches per plant varied from 9.60 (cluster I) to 17.70 (cluster IV). The cluster mean for number of internodes per plant ranged from 9.94 (cluster I) to 15.98 (cluster V).

The cluster mean for number of capitula per plant ranged from 65.75 (cluster I) to 98.44 (cluster VII). The cluster mean for number of seeds per capitula ranged from 14.39 (cluster I) to 20.14 (cluster II). The cluster mean for 1000 seed weight varied from 2.49 (cluster I) to 4.07 (cluster V). Similarly, the cluster mean for seed yield per plant ranged from 2.67 (cluster I) to 6.83 (cluster IV), whereas the cluster mean for oil content ranged from 36.79 (clusters V and VIII) to 41.74 (cluster I). Similar findings have been reported by Chatterjee (1983) [9], Sohan (1987) [37], Mehta (1989) [21], Chatterjee *et al.* (1991) [10], Jagadev and Samal (1991) [15], Biswas *et al.* (1993) [17], Ravanappa *et al.* (1994), Kumar (1999) [34], Sreedhar *et al.* (2006) [39], Parameshwarappa *et al.* (2009, 2011) [26, 27], Sangita *et al.* (2012), Goyal and Bisen (2017) [13], Misganaw (2017) [22], Naik *et al.* (2018) [23], Suryanarayana *et al.* (2018b) [40], and Suryanarayana *et al.* (2019) [41].

Table 1: Analysis of variance for ten different characters in Niger.

Sr. No.	Characters	Mean sum of squares		
		Replication (d.f.1)	**Genotype (d.f.34)**	**Error (d.f.34)**
1.	Days to 50 % flowering	0.500	109.049**	1.525
2.	Days to maturity	2.282	109.433**	1.939
3.	Plant height	0.993	308.638**	2.225
4.	Branches per plant	0.704	0.738	0.337
5.	Internode per plant	0.344	0.623	0.476
6.	Capitula per plant	1.706	200.459**	1.872
7.	Seeds per capitula	0.157	17.158**	0.467
8.	1000 seed weight	0.151	16.080**	0.211
9.	Seed yield per plant	0.003	9.500**	0.216
10.	Oil content(%)	0.645	8.360**	0.601

*and** indicate significant at 5 and 1 per cent level, respectively

Table 2: Estimates of variability parameters for seed yield and its contributing characters in thirty five niger genotypes

Sr. No.	Character	Mean	Range	GCV (%)	PCV (%)	ECV (%)	Heritability (bs) (%)	Genetic Advance	Genetic Advance % of Mean
1	Days to 50 per cent flowering	70.193	80.6-56.2	10.446	10.593	1.760	97.2	14.895	21.219
2	Days to maturity	100.918	112.44-86.9	7.264	7.394	1.380	96.5	14.837	14.702
3	Plant height (cm)	167.854	198.96-152.86	7.374	7.427	0.889	98.6	25.315	15.081
4	Number of branches/ plant	12.851	18.02-9.11	21.830	22.294	4.521	95.9	5.659	44.037
5	Number of internodes/ plant	11.760	15.98-9.04	18.062	18.992	5.869	90.4	4.162	35.387
6	Number of capitula/plant	82.694	99.67-68.56	8.842	8.925	1.214	98.1	20.336	18.046
7	Number of seeds/capitula	18.058	22.55-12.06	9.694	9.962	2.294	94.7	5.791	19.433
8	1000 seed weight (g)	3.363	4.17-2.24	15.274	20.494	13.664	55.5	0.789	23.450
9	Seed yield /plant (g)	5.254	7.89-2.37	12.397	17.816	12.795	48.4	0.646	17.771
10.	Oil content (%)	39.419	42.89-35.97	4.997	5.370	1.967	86.6	3.776	9.578

Table 3: Grouping of thirty-five genotypes of niger into different clusters based on D^2 values

Cluster No.	Number of genotypes	Name of Genotypes
I	7	IGPN-1946, IGPN-1705, IGPN-1901, IGPN-1834, IGPN-1808, IGPN-2007, IGPN-1502
II	8	IGPN-2008, IGPN-2004, IGPN-1701, IGPN-1826, IGPN-1947, IGPN-1827, IGPN-1948, IGPN-1926
III	7	IGPN-1807, IGPN-1832, IGPN-1931, IGPN-8004 (Phule Vaitarna), IGPN-1829, IGPN-1702, IGPN-2004-1 (Phule Karala)
IV	3	IGPN-1822, IGPN-1802, IGPN-1932
V	1	IGPN-1408
VI	5	IGPN-1803, IGPN-1810, IGPN-1809, IGPN-1703, IGPN-76 (Sahyadri)
VII	3	IGPN-1833, IGPN-1801, IGPN-2002
VIII	1	IGPN-1823

Table 4: Average intra (bold) and inter cluster $(D)^2$ values for eight clusters in thirty five niger genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII
I	12.01	71.18	35.36	199.77	216.34	107.70	171.53	135.49
II		17.38	41.87	136.82	155.97	43.32	104.88	72.70
III			15.85	170.51	187.61	77.94	142.01	105.95
IV				21.55	28.62	99.39	50.60	65.76
V					0.00	119.22	73.94	84.15
VI						24.00	68.25	38.02
VII							17.72	46.48
VIII								0.00

Table 5: Mean values of the eight clusters for ten characters in thirty five niger genotypes

Cluster No.	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of internodes per plant	Number of capitula per plant	Number of seeds per capitula	1000 seed weight (g)	Seed yield per plant (g)	Oil content (%)
I	78.77	109.71	154.84	9.60	9.94	69.75	14.39	2.49	2.67	41.74
II	71.53	102.14	164.63	12.94	10.89	83.14	20.14	3.75	6.24	38.62
III	75.18	105.73	159.91	10.52	10.14	75.35	17.89	3.35	4.57	40.48
IV	57.09	87.69	192.18	17.70	15.67	97.58	17.85	3.93	6.83	37.06
V	56.20	87.44	198.96	16.92	15.98	97.69	17.05	4.07	6.77	36.79
VI	67.07	97.93	171.60	14.19	12.48	87.64	19.61	3.41	5.92	39.09
VII	60.17	90.86	180.73	16.35	14.83	98.44	19.96	3.38	6.66	38.32
VIII	63.62	94.22	178.98	15.43	14.10	89.43	18.33	3.77	6.17	36.79
Population mean	60.20	96.96	174.85	14.20	13.00	87.37	18.15	3.51	5.72	38.61

Table 6: Per cent Contribution of different characters

Sr. No.	Character	Contribution (%)
1	Days to 50% flowering	0.68
2	Days to maturity	2.67
3	Plant height	50.94
4	No of branches per plant	0.67
5	No of internodes per plant	0.17
6	No of capitula per plant	13.11
7	No of seeds per capitula	2.18
8	1000 seed weight	2.40
9	Seed yield per plant	26.18
10	Oil content	1.34
	Total	100

Conclusion

The present investigation revealed substantial genetic variability among the thirty-five niger genotypes, as indicated by significant differences for all characters except number of branches per plant and number of internodes per plant. The estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) indicated the presence of adequate variability for important quantitative traits, providing scope for effective selection. High heritability coupled with high genetic advance as per cent of mean for days to 50 per cent flowering, number of branches per plant, and number of internodes per plant suggested the predominance of additive gene action and the effectiveness of selection for their improvement. Mahalanobis D^2 analysis grouped the genotypes into eight distinct clusters, revealing considerable genetic divergence. The wide inter-cluster distances and variation in cluster means indicated the availability of genetically diverse parents for hybridization. Overall, the results provide valuable information for selecting superior genotypes and developing improved niger varieties through an efficient breeding programme. The present investigation revealed no parallelism between genetic diversity and the geographical distribution of the genotypes. Based on inter-cluster distances, cluster means, and per se performance, the genotypes IGPN-1408, IGPN-1802, IGPN-2008, IGPN-2004, IGPN-2002, IGPN-1823, IGPN-1810, and IGPN-1926 were identified as superior. These genotypes may be utilized as potential parents in future hybridization programmes for crop improvement.

References

1. Ahmad E, Ram S, Kerketta V, Singh DN. Genetic association, heritability and genetic advance in Niger (*Guizotia abyssinica* (L.f) Cass.). Journal of Research, Birsa Agricultural University. 2003;15(2):251–254.
2. Ahmad E, Singh MK, Paul A, Ansari AM, Singh DN. Genetic studies of yield and yield component of niger (*Guizotia abyssinica* Cass.) in rainfed condition of western plateau of Jharkhand. International Journal of Tropical Agriculture. 2016;34(4):1127–1133.
3. Allard RW. Principles of plant breeding. New York: John Wiley and Sons, Inc.; 1960. p. 20–24, 88–89.
4. Baghel K, Salam JL, Kanwar RR, Bhanwar RR. Genetic variability analysis of yield and its components in Niger (*Guizotia abyssinica* (L. f.) Cass.). International Journal of Current Microbiology and Applied Sciences. 2018;7(8):4266–4276.
5. Bamrotiya MM, Patel JB, Malav A, Chetariya CP, Ahir D, Kandiraya J. Genetic variability, character association and path analysis in sesame [*Sesamum indicum* L.]. International Journal of Agriculture Sciences. 2016;8(54):2912–2916.
6. Bhoite KD, Chaure J, Pardeshi S. Genetic variability and diversity in Niger [*Guizotia abyssinica* (L.f.) Cass.]. The Pharma Innovation Journal. 2023;12(6):5198–5202.
7. Biswas BK, Saha MK, Alam MS, Rahman MM. Genetic divergence analysis in Niger (*Guizotia abyssinica* (L.f.) Cass). Annals of Bangladesh Agriculture. 1993;3(1):51–53.
8. Borole RD, Patil HS. Genetic variability, correlation and path analysis in Niger. Journal of Oilseeds Research. 1997;14(1):40–43.
9. Chatterjee A. Character association genetic divergence in Niger [M.Sc. Agriculture thesis]. Jabalpur (MP), India: Jawaharlal Nehru Krishi Vishwa Vidyalaya; 1983.
10. Chatterjee A, Khare D. Multivariate analysis in Niger (*Guizotia abyssinica* Cass). Research and Development Reporter. 1991;8(2):111–114.
11. Dudhe MY, Madhuri P, Rajguru AB, Bhoite KD. Genetic evaluation and identification of stable sunflower genotypes under semi-arid dryland conditions of Telangana and Maharashtra State. Sabrao Journal of Breeding and Genetics. 2017;49(1):83–93.
12. Fekadu Amsalu. Genetic variability correlation and path coefficient analysis of Niger seed (*Guizotia abyssinica* [L.f.] Cass.) genotypes. International Journal of Research Studies in Agricultural Sciences. 2020;6(3):8–16.
13. Goyal VK, Bisen R. Assessment of genetic divergence in Niger germplasm. International Journal of Chemical Studies. 2017;5(4):1482–1485.
14. Gururaja M, Nandini R, Savithramma DL, Rangaiah S, Haranikumar KM. Genetic variability for seed yield and its component traits in germplasm lines of Niger [*Guizotia abyssinica* (L. f.) Cass.]. The Pharma Innovation Journal. 2021;10(12):1854–1857.
15. Jagadev PN, Samal KM. Multivariate analysis in Niger. Indian Journal of Genetics and Plant Breeding. 1991;51(4):392–394.
16. Kenjale HB, Patil HS, Purkar JK, Dhadge SM, Lende NS. Nature and magnitude of variability and association of Niger. Journal of Oilseeds Research. 2003;20(2):349.
17. Kumar V, Bisen R. Genetic study for yield and yield attributing traits in Niger germplasm. International Journal of Agriculture Sciences. 2016;8(45):1706–1709.
18. Teja CB, Bhoite KD, Damse DN, Shinde PY. Studies on genetic variability, character association and path analysis in Niger (*Guizotia abyssinica* L.f. (Cass)) genotypes. Journal of Oilseeds Research. 2024;56(8):3044–3046.
19. Mahalanobis PC. A statistical study at Chinese head measurement. Journal of the Asiatic Society of Bengal. 1928;25:301–377.
20. Mathur RK, Gupta SC. Yield component analysis and its implication for selection in Niger (*Guizotia abyssinica* (L.f.) Cass). Journal of Oilseeds Research. 1993;10(1):6–10.
21. Mehta JL. Studied on genetic variability and diversity in Niger (*Guizotia abyssinica* (L.f.) Cass) [M.Sc. Agriculture thesis]. Dapoli (MS), India: Balasaheb Sawant Konkan Krishi Vidyapeeth; 1989.
22. Misganaw Abebaw, Abera Solomon. Genetic diversity assessment of *Guizotia abyssinica* using EST derived simple sequence repeats (SSRs) markers. African Journal of Plant Science. 2017;11(4):79–85.
23. Naik GH, Ghodke MK, Chavan TA. Genetic diversity analysis in Multihead inbred lines of sunflower (*Helianthus annuus* L.). International Journal of Current Microbiology and Applied Sciences. 2018;7(10):324–329.
24. Panda S, Sial P. Assessment of existing genetic variability and yield component analysis in Niger (*Guizotia abyssinica* Cass). Indian Journal of Innovations and Developments. 2012;1(7):511–514.

25. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 4th ed. New Delhi: Indian Council of Agricultural Research; 1995. p. 145–150.
26. Parameshwarappa SG, Palakshappa MG, Gayatree GS. Genetic diversity studies in germplasm collections of Niger. Plant Archives. 2011;11(2):1071–1074.
27. Parameshwarappa SG, Salimath PM, Palakshappa MG. Assessment of genetic diversity in Niger (*Guizotia abyssinica* (L.f.) Cass). Karnataka Journal of Agricultural Sciences. 2009;22(4):879–880.
28. Patil HE, Mali RS, Giri AR, Thawari SB. Genetic improvement in niger (*Guizotia abyssinica* Cass.) by using study of variability, correlation and path analysis. International Journal of Agricultural Sciences. 2013;9(2):671–673.
29. Patil HS. Yield component analysis in niger (*Guizotia abyssinica* Cass). Madras Agricultural Journal. 2000;87(4-6):260–263.
30. Patil HS. Multivariate analysis as aid to genotype selection for breeding in Niger (*Guizotia abyssinica* Cass). Indian Journal of Crop Improvement. 2007;34(2):202–205.
31. Patil HS, Duhoon SS. Nature of variability, association and path analysis in Niger. Journal of Oilseeds Research. 2005;22(2):438–449.
32. Ram JJ, Singh UK, Singh SK, Krishna B. Study of genetic diversity in sunflower (*Helianthus annuus* L.). International Journal of Current Microbiology and Applied Sciences. 2018;7(5):2266–2272.
33. Rao CR. Advanced statistical methods in biometric research. New York: John Wiley and Sons Inc.; 1952. p. 390.
34. Ravanappa TM. Multivariate analysis in Niger (*Guizotia abyssinica* Cass.) [M.Sc. Agriculture thesis]. Bangalore (Karnataka), India: University of Agricultural Sciences, GKVK; 1994.
35. Yadav S, Kumar S, Hussain Z, Suneja P, Yadav SK, Nizar MA, *et al*. *Guizotia abyssinica* (L.f.) Cass.: An untapped oilseed resource for the future. Biomass and Bioenergy. 2012;43:72–78.
36. Sivasubramanian V, Madhavamenon P. Path analysis for yield and yield components of rice. Madras Agricultural Journal. 1973;60(9-12):1217–1221.
37. Sohan R. Correlation and divergence studies in Niger (*Guizotia abyssinica* L.) [M.Sc. Agriculture thesis]. Ranchi, India: Birsa Agricultural University; 1987.
38. Sreedhar RV. Assessment of genetic variability in Niger (*Guizotia abyssinica* Cass.) [M.Sc. Agriculture thesis]. Dharwad, India: University of Agricultural Sciences; 2003.
39. Sreedhar RV, Gangaprasad S, Ravikumar RL, Salimath PM. Assessment of genetic diversity in niger, (*Guizotia abyssinica* (L.f.) Cass). Journal of Oilseeds Research. 2006;23(2):191–193.
40. Suryanarayana L, Sekhar D, Tejeswara Rao K. Genetic divergence studies in Niger (*Guizotia abyssinica* L.) genotypes. Journal of Pharmacognosy and Phytochemistry. 2018;7(5):725–727.
41. Suryanarayana L, Sekhar D, Tejeswara Rao K. Assessment of genetic divergence in Niger (*Guizotia abyssinica* L.). International Journal of Chemical Studies. 2019;7(3):4061–4063.
42. Valli S, Chourat S, Rani RJ, Rajeswari R. Correlation and path coefficient analysis for the yield components of Safflower germplasm (*Carthamus tinctorius* L.). Electronic Journal of Plant Breeding. 2016;7(2):420–426.