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Studies on genetic variability, character association and path analysis in Niger {*Guizotia abyssinica* Lf. (Cass)} genotypes

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Abstract
The present investigation was carried out to study the genetic variability parameters and nature of associations among the traits affecting grain yield in thirty niger genotypes at Botany division research farm, College of Agriculture Pune, Maharashtra during *kharif*, 2022. High estimates of genotypic coefficient of variation and phenotypic coefficient of variation were observed for number of branches per plant, number of capitula per plant, number of seeds per plant and seed yield per plant. High heritability coupled with high genetic advance was observed for number of branches per plant, number of capsules per plant, number of seeds per capsule and grain yield suggesting that they can be improved through direct selection due to predominant additive variation. Correlation studies revealed that plant height, number of capitula per plant and test weight exhibited highly significant positive correlation with grain yield both at phenotypic and genotypic level. Path coefficient analysis showed that plant height, number of seeds per capitula had the maximum direct effect on grain yield followed by number of capitula per plant.

Keywords: Genetic variability, heritability, character association, path analysis in Niger

Introduction
Niger {*Guizotia abyssinica* Lf. (Cass)} although considered a minor oilseed crop, is important in terms of its 32 to 40% content of quality oil with 18 to 24% protein in the seed. Niger crop is important in terms of proteins and quality oil, the oil is used for culinary purposes, manufacturing of paints, soft soaps, lighting and lubrication. The seeds are eaten fried, used as condiment or dried powder and mixed with flour to make sweet cakes. Niger seeds contain about 40% edible oil with a fatty acid composition of 75-80% linoleic acid, 7-8% palmitic and steric acids, and 5-8% oleic acid. However, keeping quality of Niger is poor due to high content of unsaturated fatty acids.

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 a larger area in Chhattisgarh, MP, Maharashtra and Odisha. It can be grown successfully without chemicals. The crop is capable of giving better yield even under low soil fertility, moisture and poor crop management and show good resistance to biotic factors.

The Niger must greatly increase its seed yield in order to compete with other oilseed crops. To accomplish this goal, single-headed, dwarf varieties that mature uniformly and experience fewer shattering losses must be produced. Boosting the seed oil content is the second most crucial breeding goal for Niger development.

The quantum of genetic variability present in the population will determine the breeding strategy to be adopted for crop improvement. In addition to the genetic variability, knowledge on heritability and genetic advance helps the breeder to employ the suitable breeding strategy. Therefore, it is necessary to have knowledge on genetic variability, heritability and genetic advance present in the available genetic material. The correlation studies simply measure the associations between yield and other traits. Whereas, path analysis permits the understanding of cause and effect of related characters.

Materials and Methods

The field experiment was conducted at Botany division research farm, College of Agriculture Pune, Maharashtra during *kharif*, 2022. Thirty Niger genotypes were raised in Randomized Block Design (RBD) in two replications with spacing of 30 × 15 cm. Each genotype was grown in 2 lines of 5 m length. To raise a healthy crop all the recommended package of practices were followed and observations were recorded for Days to 50 percent flowering, Days to maturity, Plant height (cm), Number of branches per plant, Diameter of capitulam, Number of capsules per plant, Number of seeds per capsule, Test weight, Grain yield and Oil content.

The data was subjected to statistical analysis to estimate genetic parameters (Panse and Sukhatme, 1995) [13], phenotypic and genotypic coefficients of variation (PCV and GCV) according to Burton (1952) [7] and Johnson (1955) [10], heritability in broad sense as per Burton (1952) [7]. Genetic advance and genetic advance expressed as percent of mean was estimated as per the formula proposed by Johnson *et al*.(1955) [10]. Correlation coefficients were worked out using the formula as suggested by Singh and Chaudhary (1977) [20] and was partitioned into direct and indirect causes according to Dewey and Lu (1959) [8].

Results and Discussion

The analysis of variance revealed highly significant differences among the thirty genotypes for nine characters except for diameter of the capitulum indicating the existence of sufficient amount of variability among the genotypes (Table.1) for the characters studied. The highest genotypic coefficient of variation was observed for seed yield per plant (43.48%) followed by number of capitulum per plant (32.11%) and number of seeds per capitulum (29.71%). The characters number of branches per plant (18.47%), test weight (16.14%), diameter of capitulum (10.73%) and oil content (10.59%) exhibited medium genotypic coefficient of variation. While Low GCV were observed for plant height (6.08%) followed by days to 50% flowering (5.95%) and days to maturity (4.21%). This was in the conformity with the results of Bhoite *et al*. (2023) [5] and Baghel *et al*.(2018) [2].

Generally the estimates of phenotypic coefficients of variation were higher than the genotypic coefficients of variation, it indicates the variation was not only due to genotypes but also due to the influence of environment. The findings of Bhoite *et al*.(2023) [5], Pushpa *et al*. (2023) [17], Saraswat *et al*. (2022) [19], Suryanarayana *et al*. (2018) [23], Baghel *et al*.(2018) [2] and Tiwari *et al*.(2016) [26] which had also observed that PCV was higher than the GCV for all characters are supported by these finding and indicating the influence of environmental factors in their expression. Some of the characters like heritability as determined by the current investigation, could be characterized as having very high heritability in agreement with Robinson *et al*. (1949) [18] classification. Almost all the characters under study recorded high heritability. The sequence of the ascending characters as follows Oil content (99.63%,) seed yield per plant (95.82%), days to maturity (93.31%), number of seeds per capitula (92.75%), days to 50% flowering (91.47%), number of capitula per plant (91.12%), test weight (91.05%) plant height (89.89%), number of branches per plant (74.02%) and diameter of capitulum (62.14%). High heritability estimates suggest that these characters were least influenced by the environment. These observations were similar to the findings by Saraswat *et al*. (2022) [19] for days to 50% flowering, days to maturity, plant height, number of branches per plant, number of capitula per plant, number of seeds/capitula, test weight and seed yield per plant. Bhoite *et al*. (2023) [5] for characters days to 50% flowering, days to maturity, plant height, number of branches per plant, number of capitula per plant, number of seeds per capitula and seed yield per plant. Suryanarayana *et al*. (2018) [23] for character like days to 50% flowering, number of capsules per plant, number of seeds per capitula. Pushpa *et al*. (2023) [17] for days to 50% flowering, number of capitula per plant and oil content. Earlier, Bilaiya (1987) [3], Mishra (1995) [11], Borole and Patil (1997) [6], Patil (2000) [14] and Sreedhar (2003) [22], also reported high estimates of heritability for number of branches per plant, number of capitula per plant, number of seed per capitula, seed yield per plant and Pradhan *et al*. (1995) [16] for days to 50% flowering.

In current study, high heritability (h2) along with higher genetic advance (GA) as % mean was recorded for the traits i.e., seed yield per plant, number of seeds per capitula, number of capitula per plant, number of branches per plant, test weight, oil content indicated that these characters were under control of additive gene actions. All of these features could be subject to selection in an effort to boost genotype magnitude. A comparable outcome was noted by Valli *et al*. (2016) [28] for test weight in safflower. The findings aligned with the anticipated outcomes as reported by Baghel *et al*. (2018) [2] in relation to the oil content and Baghel *et al*. (2018) [2] and Bamrotiya *et al*. (2016) [4] in Niger for number of branches per plant, number of capitula per plant, number of seeds/capitulum and seed yield/plant. Similar result was reported by Pushpa *et al*. (2023) [17] for number of branches per plant. Similar observations were made by Ahmad *et al*. (2016) [1] for the number of capitula per plant.

High heritability (h2) with moderate genetic advance (GA) as percent of mean showed for the characters days to 50% flowering plant height and diameter of the capitulum suggested that both additive and non-additive gene effects were involved in the genetic regulation of these traits. These results supported prior findings by Pushpa *et al*.(2023) [17], Baghel *et al*. (2018) [2] in Niger and Valli *et al*.(2016) [28] in safflower regarding days to 50% flowering.

High heritability (h2) with low genetic advance (GA) as percent of mean was displayed by days to maturity, and it was in similar agreement with Bamrotiya *et al*. (2016) [4] in Niger and Valli *et al*. (2016) [28] in safflower.

Correlation analysis revealed that the genotypic correlation coefficients were lower than their phenotypic correlation coefficients indicating the association is largely due to environmental reason. Days to 50% flowering had shown significant positive association with days to maturity and number of branches per plant. This result was in conformity with the earlier findings of Valli *et al*. (2016) [28], Bamrotiya *et al*. (2016) [4], Tadesse *et al*. (2009) [25], Panda and Sial (2012) [12] for days to maturity and Bamrotiya *et al*. (2016) [4], Panda and Sial (2012) [12] for number of branches per plant. Days to maturity had observed positive and significant association oil content. These results were in similar agreement with Tadesse *et al*. (2009) [25], and Bamrotiya *et al*. (2016) [4] for number of branches per plant. Plant height had observed significantly positive association to seed yield per plant. These results were in agreement with Bamrotiya *et al*. (2016) [4], Fazal *et al*. (2015) [9] and Tadesse *et al*. (2009) [25]. Similarly, number of branches per plant had significantly positive correlation with number of capitula per plant. This result was in conformity with the findings of Suvarna *et al*. (2019) [24].

Number of capitula per plant had significant positive association to test weight and seed yield per plant. Similar kind of association was also revealed by Fazal *et al*. (2015) [9] and

Bamrotiya *et al*.(2016) [4] for test weight and Fazal *et al*. (2015) [9] and Tadesse *et al*. (2009) [25] for seed yield per plant.

Path coefficient analysis showed that, the character days to 50% flowering (1.1448) observed maximum level of direct beneficial effect on grain yield per plant and followed by number capitula per plant (0.4020), diameter of capitulum (0.3156), test weight (0.2917), number of seeds per capitula (0.1320), number of branches per plant (0.0761), plant height (0.067) and oil content (0.0078). Hence, direct selection for these characters will be beneficial for yield improvement programme. The character days to 50% flowering (-1.1381), observed negative direct effect on seed yield per plant.

These findings were similar with reports of Suryanarayana *et al*. (2018) [23] for days to maturity, number of seeds per capitula, plant height and number of branches per plant which had shown positive direct effects on grain yield. Tsige Genet (2007) [27] and Patil *et al*. (2013) [15] and Singh *et al*.(2018) [21] reported test weight recorded positive direct effect to yield. Similar types of findings were reported by Sahoo *et al*. (2022) [19] and Patil *et al*. (2013) [15] for days to maturity and Bamrotiya *et al*. (2016) [4] for number of seeds per capitula, number of capitula per plant and number of branches per plant. Ahmad *et al*. (2016) [1] and Singh *et al*. (2018) [21] for plant height. Tsige Genet (2007) [2], Bamrotiya *et al*. (2016) [4] and Suryanarayana *et al*. (2018) [23] had observed that days to 50% flowering has shown negative direct effect on grain yield.

Table 1: Analysis of variance for 10 different characters

S. No.	Name of the Characters	Mean Sum of Squares		
		Replication (d.f. 1)	Treatments (d.f. 29)	Error (d.f. 29)
1	Days to 50% flowering	2.017	31.74**	2.017
2	Days to maturity	3.267	43.65**	3.267
3	Plant height (cm)	3.800	183.98**	3.800
4	Number of branches per plant	0.794	6.59**	0.794
5	Number of capitula per plant	0.817	857.63**	0.817
6	Diameter of capitula per plant (cm)	0.002	0.02	0.002
7	Number of seeds per capitula	5.104	62.62**	5.104
8	Seed yield per plant (g)	0.308	23.07**	0.308
9	100 grain weight (g)	0.048	0.64**	0.048
10	Oil content (%)	0.028	24.50**	0.028

*Significant at 5% level;
** Significant at 1% level.

Table 2: Estimates of genetic variability parameters for 10 different characters.

S. No.	Name of the Characters	Range	G.C.V. (%)	P.C.V. (%)	Heritability(h^2) (bs) %	GA as % of mean
1	Days to 50% flowering	57.00 – 70.00	5.95	6.23	91.47	11.73
2	Days to maturity	97.50 – 114.00	4.21	4.36	93.31	8.95
3	Plant height (cm)	128.55 – 169.75	6.08	6.41	89.89	11.87
4	Number of branches per plant	6.10 – 12.85	18.47	21.46	74.02	32.72
5	Number of capitula per plant	36.50 – 118.00	32.11	33.64	91.12	63.15
6	Diameter of capitula per plant (cm)	0.52 – 0.88	10.73	13.61	62.14	17.42
7	Number of seeds per capitula	8.85 – 29.00	29.71	30.86	92.75	58.95
8	Seed yield per plant (g)	4.25 – 15.95	43.48	44.42	95.82	87.68
9	100 grain weight (g)	2.30 – 4.50	16.14	16.91	91.05	31.73
10	Oil content (%)	26.40 – 37.55	10.59	10.62	99.63	21.78

Table 3: Genotypic (above diagonal) and Phenotypic (below diagonal) correlation coefficients of 10 characters of 30 genotypes of Niger on grain yield

Characters		Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches /plant	No. of capitula /plant	Diameter of capitulum (cm)	No. of seeds/capitula	Seed yield /Plant (g)	1000 grain weight (g)	Oil content (%)
Days to 50% flowering	**rg**	**1**	0.9812**	-0.2302	0.4129*	0.229	0.0179	-0.3053	0.0497	0.2514	**0.1181**
	rp	**1**	0.9787**	-0.2133	0.2971	0.2211	0.0182	-0.2919	0.0259	0.2370	**0.1137**
Days to maturity	**rg**		**1**	-0.2459	0.3980*	0.1800	-0.0200	-0.3253*	0.0353	0.3289*	**0.0351**
	rp		**1**	-0.2248	0.2899	0.1709	-0.0232	-0.3168*	0.0189	0.3140*	**0.0328**
Plant height (cm)	**rg**			**1**	0.1311	0.2872	0.2981	0.2539	-0.0124	-0.3701*	**0.3294***
	rp			**1**	0.0943	0.2639	0.1829	0.2358	-0.0192	-0.3528*	**0.3049**
No. of branches /plant	**rg**				**1**	0.4821**	0.2183	-0.1695	-0.0160	0.2432	**0.3422***
	rp				**1**	0.3942*	0.1868	-0.1229	0.0139	0.2125	**0.2940**
No. of capitula /plant	**rg**					**1**	0.4708**	0.0666	0.4507**	-0.2107	**0.8023****
	rp					**1**	0.4996**	0.1133	0.4174*	-0.2102	**0.8004****
Diameter of capitulum(cm)	**rg**						**1**	0.1999	0.5366**	-0.0686	**0.7670****
	rp						**1**	0.2692	0.4172*	-0.0705	**0.6931****
No. of seeds/capitula	**rg**							**1**	0.2986	-0.3656*	**0.3310***
	rp							**1**	0.2832	-0.3544*	**0.3481***
1000 grain weight (g)	**rg**								**1**	-0.2569	**0.6943****
	rp								**1**	-0.2458	**0.6649****
Oil content (%)	**rg**									**1**	**-0.3145***
	rp									**1**	**-0.3124***

*, ** Significant at 5 and 1 percent respectively

Table 4: Direct (diagonal) and indirect (above and below diagonal) path effects of different characters towards grain yield at genotypic level in Niger.

S. No.	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Number of capitula per plant	Diameter of capitulum (cm)	Number of seeds per capitula	Test weight (g)	Oil content %	Seed yield per plant(g)
	1	2	3	4	5	6	7	9	10	8
1.	1.1448**	1.1233**	-0.2636	0.4727**	0.2622	0.0205	-0.3495*	0.0569	0.2878	0.1181
2.	-1.1167**	-1.1381**	0.2798	-0.4529**	-0.2049	0.0228	0.3703*	-0.0402	-0.3743*	0.0351
3.	-0.0153	-0.0164	0.0666	0.0087	0.0191	0.0198	0.0169	-0.0008	-0.0246	0.3294*
4.	0.0314	0.0303	0.01	0.0761	0.0367	0.0166	-0.0129	-0.0012	0.0185	0.3422*
5.	0.0921	0.0724	0.1154	0.1938	0.4020*	0.1892	0.0268	0.1812	-0.0847	0.8023**
6.	0.0057	-0.0063	0.0941	0.0689	0.1486	0.3156*	0.0631	0.1694	-0.0217	0.7670**
7.	-0.0403	-0.0430	0.0335	-0.0224	0.0088	0.0264	0.1320	0.0394	-0.0483	0.3310*
9.	0.0145	0.0103	-0.0036	-0.0047	0.1315	0.1565	0.0871	0.2917	-0.0749	0.6943**
10.	0.0020	0.0026	-0.0029	0.0019	-0.0016	-0.0005	-0.0028	-0.0020	0.0078	-0.3145*

(Residual effect = 0.22) *, ** Significant at 5 and 1 percent respectively

Conclusion

In the present investigation high heritability coupled with high genetic advance was observed for number of branches per plant, number of capsules per plant, number of seeds per capsule and grain yield suggesting that they can be improved through direct selection due to predominant additive variation. Genetic advance a percent mean recorded high for seed yield per plant, number of seeds per capitula, number of capitula per plant, number of branches per plant, test weight, oil content. Selection may be effective in such cases. Correlation analysis revealed that number of capitula per plant had significant positive association to test weight and seed yield per plant.

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