

MORPHOMETRICS OF GENUS CASSIA L. FROM KOLHAPUR DISTRICT

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ABSTRACT

Morphometric study of ten different species of *Cassia* L. from Kolhapur District was performed with respect to the fourteen different quantitative characters; which includes leaf length, leaflet length, leaflet width, leaflet length/ leaflet width, petiole length, pedicel length, petal length, petal width, fruit length, fruit width, fruit length/ fruit width, seed length, seed width and seed length/ seed width. The dimensions of quantitative characters were measured and subjected to the principal component analysis (PCA) and cluster analysis. PCA results reveals the correlation between all quantitative characters mentioning that four characters which are related with the leaf *i.e.* leaf length, leaflet length, leaflet width and leaflet length/leaflet width are significant in delimitation of the *Cassia* L. species. Cluster analysis and dendrogram on the basis of farthest neighbor, mean character difference and constrained clustering strategy shows that the dissimilarities in between *Cassia abscurus* L. and *Cassia alata* L. is greater while that in between *Cassia sophera* L. and *Cassia occidentalis* L. is minimum. Coefficients of Difference values of all the species reveal that *Cassia abscurus* L. and *Cassia siamea* Lamk. are distinctly separate from each other as they with more significant CD and *Cassia occidentalis* L. and *Cassia sophera* L. are closely related with each other, as well as quantitative characters like seed length/ seed width, fruit length/ fruit width, fruit width and petal width has vital contribution in differentiation of the taxa.

INTRODUCTION

Cassia L. *sensu lato*. is one of the twenty five largest genera of dicotyledonous plants which occur naturally in the tropics around the world (Boonkerd *et al.*, 2005). Kolhapur is the extreme Southern district of Maharashtra State, situated between 17° 17' to 15° 43' NL and 73° 40' and 74° 42' EL from where, 19 different *Cassia* L. species including one variety have been recorded (Yadav and Sardesai, 2002). The genus comprise trees, shrubs or herbs which are characterized by having abruptly pinnate leaves with various types of stipules, rachis furnished with glands either in between the leaflets or on the petiole, inflorescence axillary or terminal racemes or panicles, stamens unequal normally 10 all perfect, or 3-5 imperfect, ovary sessile or stalked, pod variable, terete or flat (Cooke, 1901).

Cassia L. species are not easily differentiated from each other; their taxonomy and nomenclature are quite complex due to overlapping morphological characters and great range of similarities present in between them (Kumar *et al.*, 2007). This usually leads to mis identification and mis interpretation of the components (Singh, 2001). Majority of the *Cassia* L. species have long history of economic importance, especially as medicinal plants (Burkill, 1935), so its proper taxonomy has great significance. Morphometrics permits numerical comparison between different forms and it has great significance in distinct grouping or separation of closely related species.

MATERIALS AND METHODS

Ten different *Cassia* L. species were collected from various

regions of Kolhapur district during the years 2009 and 2010. Collected species were identified with the help of standard literature. Measurements of various quantitative characters (*viz.* leaf length, leaflet length, leaflet width, petiole length, pedicel length, petal length, petal width, fruit length, fruit width, seed length and seed width) were taken with the help of thread and line ruler. Mean values were obtained and processed for principal component analysis and cluster analysis by keeping data standardized at similarity matrix and tolerance of Eigen analysis set at 1E-010. The coefficient of difference (CD) was calculated for all the characters in between all the taxa according to Mayr (1969).

RESULTS AND DISCUSSION

Principal component analysis and cluster analysis are widely used in the field of numerical taxonomy (Soladoye *et al.*, 2010). Present study deals with the ten different *Cassia* species widely distributed in Kolhapur district, these are *Cassia abscurus* L., *Cassia alata* L., *Cassia auriculata* L., *Cassia obtusifolia* L., *Cassia occidentalis* L., *Cassia simea* Lamk., *Cassia sophera* L., *Cassia surrattensis* Burm.f. spp. *glauca* (Lam.) K.& S., *Cassia tora* L. and *Cassia uniflora* Mill. Various quantitative characters alongwith their mean are tabulated in Table 1. The results obtained from PCA shows that four characters which are related with the leaf *i.e.* leaf length, leaflet length, leaflet width and leaflet length/leaflet width are significant in delimitation of the *Cassia* L. species as their eigenvalue is greater than 1 represented in Table 2 and Fig. 1.

PCA results (Table 4) also reveals the correlation between leaf length and seed length/ seed width, leaf length and leaflet length, leaf length and leaflet width, leaf length and petiole

Table 1: Quantitative characters of *Cassia* L. species with mean and standard deviation

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
LL	3.21 ± 1.8	39.65 ± 21.20	7 ± 1.9	6.1 ± 4	14.17 ± 7.49	16.6 ± 5.4	13.86 ± 3.15	13.95 ± 3.05	5.3 ± 2.52	4.43 ± 1.65
LEL	2.84 ± 1.67	8.25 ± 5.77	1.6 ± 0.95	3.75 ± 2.25	4.75 ± 1.6	5.4 ± 0.3	5.75 ± 1.65	6.51 ± 2.1	2.75 ± 1.4	3.45 ± 1.15
LEW	1.59 ± 0.91	5.3 ± 3.22	0.9 ± 0.4	2.25 ± 1.75	1.7 ± 0.8	2.3 ± 0.20	1.74 ± 0.35	3.04 ± 0.45	2.6 ± 0.85	1.47 ± 0.55
LEL/LEW	1.78 ± 0.38	1.55 ± 1.275	1.77 ± 2.75	1.66 ± 0.25	2.79 ± 1.4	3.3 ± 1	3.3 ± 1	2.13 ± 0.82	1.05 ± 2.75	2.34 ± 0.3
PETL	2.85 ± 0.57	5.8 ± 2.21	1.12 ± 0.24	1.75 ± 0.25	3.67 ± 1.15	3.25 ± 1.1	3.88 ± 0.75	4.72 ± 1.45	2.57 ± 1.34	1.84 ± 0.55
PED	0.54 ± 0.17	0.9 ± 0.13	2.5 ± 0.1	2 ± 1	1 ± 0.5	2.1 ± 0.95	1.61 ± 0.55	2.86 ± 0.5	0.95 ± 0.2	0.35 ± 0.05
PEL	0.65 ± 0.25	2 ± 0.8	2 ± 0.5	0.95 ± 0.15	2 ± 0.5	1.65 ± 0.47	2.24 ± 0.2	3.47 ± 0.75	0.98 ± 0.34	0.5 ± 0.1
PEW	0.51 ± 0.05	1.4 ± 0.2	1.1 ± 0.22	0.5 ± 0.1	1.2 ± 0.3	1.05 ± 0.07	1.32 ± 0.3	2.29 ± 0.50	0.75 ± 0.06	0.35 ± 0.05
FL	3.15 ± 1.12	14.7 ± 3.30	10.25 ± 2.5	13 ± 6	9.95 ± 4.45	19.95 ± 9	9.98 ± 0.75	16.15 ± 3.2	14.54 ± 3.76	3.45 ± 1.25
FW	0.55 ± 0.03	1.5 ± 0.35	1.5 ± 0.2	0.55 ± 0.05	0.8 ± 0.2	1.35 ± 0.26	0.81 ± 0.15	1.44 ± 0.2	0.5 ± 0.2	0.35 ± 0.05
FL/FW	5.72 ± 0.54	9.8 ± 1.475	6.83 ± 1.15	23.63 ± 2.2	12.43 ± 1.97	14.77 ± 4.37	12.32 ± 0.3	11.2 ± 1.5	29.08 ± 1.78	9.85 ± 0.6
SL	0.42 ± 0.085	0.6 ± 0.1	0.95 ± 0.55	0.57 ± 0.15	0.4 ± 0.05	0.85 ± 0.35	0.35 ± 0.05	0.6 ± 0.1	0.42 ± 0.08	0.45 ± 0.05
SW	0.32 ± 0.073	0.15 ± 0.05	0.45 ± 0.05	0.32 ± 0.12	0.3 ± 0.04	0.48 ± 0.1	0.25 ± 0.025	0.35 ± 0.05	0.27 ± 0.05	0.35 ± 0.04
SL/SW	1.31 ± 0.006	4 ± 0.025	2.11 ± 0.25	1.73 ± 1.25	1.33 ± 0.015	1.77 ± 0.125	1.4 ± 0.0125	1.71 ± 0.025	1.52 ± 0.015	1.28 ± 0.05

LL: leaflet length, LEL: leaflet length, LEW: leaflet width, LEL/LEW: leaflet length/ leaflet width, PETL: petiole length, PED: pedicel length, PEL: petal length, PEW: petal width, FL: fruit length, FW: fruit width, FL/FW: fruit length/ fruit width, SL: seed length, SW: seed width, SL/SW: seed length/ seed width; C1: *Cassia abscus* L., C2: *Cassia alata* L., C3: *Cassia auriculata* L., C4: *Cassia obtusifolia* L., C5: *Cassia occidentalis* L., C6: *Cassia siamea* Lamk., C7: *Cassia sophera* L., C8: *Cassia surattensis* Burm.f.ssp glauca (Lam.) K. & S., C9: *Cassia tora* L., C10: *Cassia uniflora* Mill.

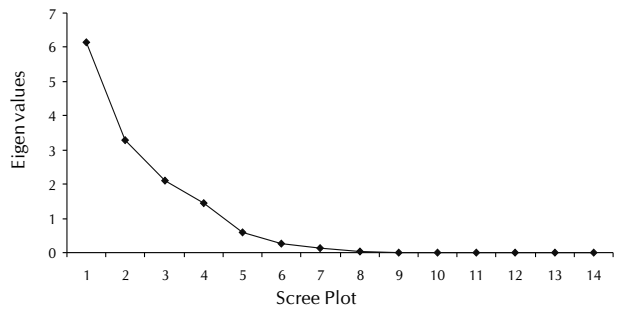


Figure 1: Scree plot showing graphical representation of Eigen values and respective quantitative characters from Table 2.

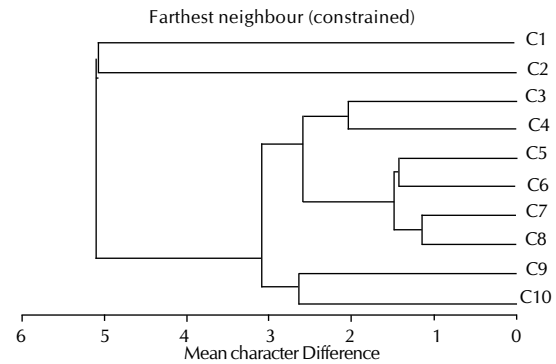


Figure 2: Dendrogram on the basis of mean character difference observed in quantitative characters; C1: *Cassia abscus* L., C2: *Cassia alata* L., C3: *Cassia auriculata* L., C4: *Cassia obtusifolia* L., C5: *Cassia occidentalis* L., C6: *Cassia siamea* Lamk., C7: *Cassia sophera* L., C8: *Cassia surattensis* Burm.f.ssp glauca(Lam.)K.&S., C9: *Cassia tora* L., C10: *Cassia uniflora* Mill.

length, leaflet length and petiole length, leaflet length and leaflet width, leaflet width and seed length/ seed width, leaflet width and petiole length, petal length and petal width, petal length and fruit width, petal width and fruit width and fruit width and seed length. Evaluation of coefficient of difference values (Table 3) determines that *Cassia abscus* L. and *Cassia siamea* Lamk. shows more significant CD and *Cassia occidentalis* L. and *Cassia sophera* L. are with less CD than the other ones; as well as quantitative characters seed length/ seed width, fruit length/ fruit width, fruit width and petal width has vital contribution in differentiation of the taxa respectively. Cluster analysis and dendrogram (Table 5 and Fig. 2) on the basis of farthest neighbor, mean character difference and constrained clustering strategy shows that the dissimilarities in between *Cassia abscus* L. and *Cassia alata* L. is greater i.e.5.069 while that in between *Cassia sophera* L. and *Cassia occidentalis* L. is minimum i.e. 0.240 indicating both the species are closely related.

Above results follow the Linnaeus system of classification for *Cassia* L. species but by determining CD values we can conclude that *Cassia abscus* L. is significantly different from most of the species which justifies Irwin and Barneby's (1981, 1982) work, who have supported a division of genus *Cassia* into three genera, namely *Cassia* L., *Chamaecrista* Moench and *Senna* Mill. and they have separated *Cassia abscus* L. into new genus i. e. *Chamaecrista* Moench.

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Table 2: Variance in studied quantitative characters

	LL	LEL	LEW	LEL/LEW	PETL	PED	PEL	PEW	FL	FW	FL/FW	SL	SW	SL/SW
Eigenvalues	6.153	3.297	2.097	1.447	0.579	0.26	0.13	0.033	0.003	0	0	0	0	0
% of variance	43.952	23.551	14.976	10.336	4.136	1.857	0.931	0.236	0.025	0	0	0	0	0
Cum. percentage	43.952	67.504	82.480	92.815	96.951	98.808	99.739	99.975	100	100	100	100	100	100

Table 3: Coefficient of difference in between all the plant groups

Sr. No.	PG	LL	LEL	LEW	LEL/LEW	PETL	PED	PEL	PEW	FL	FW	FL/FW	SL	SW	SL/SW	Total
1	C1&C2	*						*	*	*	*	*	*	*	*	9
2	C1&C3					*	*	*	*	*	*	*			*	7
3	C1&C4					*						*				2
4	C1&C5							*	*			*				3
5	C1&C6	*	*		*		*	*	*	*	*	*			*	10*
6	C1&C7	*				*	*	*	*	*	*	*			*	8
7	C1&C8	*				*	*	*	*	*	*	*	*		*	9
8	C1&C9							*	*			*			*	4
9	C1&C10							*	*		*	*			*	4
10	C2&C3	*				*	*						*	*	*	5
11	C2&C4	*				*		*	*		*	*		*	*	7
12	C2&C5								*				*	*	*	3
13	C2&C6							*	*				*	*	*	3
14	C2&C7								*	*	*	*	*	*	*	5
15	C2&C8					*	*		*	*	*	*	*	*	*	3
16	C2&C9	*						*	*		*	*		*	*	5
17	C2&C10	*				*	*	*	*	*	*	*	*	*	*	9
18	C3&C4					*	*	*	*		*	*			*	6
19	C3&C5					*	*	*	*		*	*	*	*	*	6
20	C3&C6	*	*	*	*	*	*	*	*		*	*	*	*	*	6
21	C3&C7		*			*	*	*	*		*	*	*	*	*	7
22	C3&C8	*	*	*	*	*	*	*	*		*	*	*	*	*	7
23	C3&C9			*	*	*	*	*	*		*	*	*	*	*	7
24	C3&C10					*	*	*	*	*	*	*	*	*	*	7
25	C4&C5					*	*	*	*		*	*	*	*	*	4
26	C4&C6							*	*		*	*	*	*	*	3
27	C4&C7		*		*	*	*	*	*		*	*	*	*	*	7
28	C4&C8					*	*	*	*		*	*	*	*	*	5
29	C4&C9							*	*		*	*	*	*	*	2
30	C4&C10						*	*	*	*	*	*	*	*	*	4
31	C5&C6										*	*	*	*	*	2
32	C5&C7										*	*	*	*	*	1*
33	C5&C8							*	*		*	*	*	*	*	3
34	C5&C9								*		*	*	*	*	*	2
35	C5&C10						*	*	*	*	*	*	*	*	*	4
36	C6&C7								*	*	*	*	*	*	*	3
37	C6&C8						*	*	*	*	*	*	*	*	*	2
38	C6&C9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	7
39	C6&C10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	8
40	C7&C8			*	*	*	*	*	*	*	*	*	*	*	*	7
41	C7&C9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	5
42	C7&C10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	9
43	C8&C9	*	*	*	*	*	*	*	*	*	*	*	*	*	*	7
44	8&C10	*	*	*	*	*	*	*	*	*	*	*	*	*	*	9
45	9&10			*	*	*	*	*	*	*	*	*	*	*	*	6
	Total	16	7	5	7	15	16	21	28	14	28	30	6	16	33	

*: significant CD (> 1.28); LL: leaf length, LEL: leaflet length, LEW: leaflet width, LEL/LEW: leaflet length/leaflet width, PETL: petiole length, PED: pedicel length, PEL: petal length, PEW: petal width, FL: fruit length, FW: fruit width, FL/FW: fruit length/fruit width, SL: seed length, SW: seed width, SL/SW: seed length/seed width; PG: plant groups, C1: *Cassia abscondita* L., C2: *Cassia alata* L., C3: *Cassia auriculata* L., C4: *Cassia obtusifolia* L., C5: *Cassia occidentalis* L., C6: *Cassia simea* Lamk., C7: *Cassia sophera* L., C8: *Cassia surattensis* Burm.f.ssp glauca (Lam.) K.&S., C9: *Cassia tora* L., C10: *Cassia uniflora* Mill.

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Table 4: Principal components analysis of *Cassia* L. species using quantitative characters (Tolerance of eigen analysis set at 1E-010)

Similarity matrix	LL	LEL	LEW	LEL/LEW	PETL	PED	PEL	PEW	FL	FW	FL/FW	SL	SW	SL/SW
LL	1.000													
LEL	0.864	1.000												
LEW	0.846	0.791	1.000											
LEL/LEW	0.033	0.279	-0.351	1.000										
PETL	0.824	0.926	0.787	0-.181	1.000									
PED	0.011	0.098	-0.054	0.070	-0.017	1.000								
PEL	0.454	0.574	0.289	0.331	0.591	0.691	1.000							
PEW	0.508	0.639	0.407	0.244	0.688	0.611	0.982	1.000						
FL	0.470	0.478	0.512	-0.166	0.384	0.612	0.515	0.533	1.000					
FW	0.631	0.475	0.408	-0.006	0.451	0.645	0.750	0.739	0.603	1.000				
FL/FW	-0.198	-0.134	0.131	-0.390	-0.182	0.031	-0.242	-0.224	0.445	-0.384	1.000			
SL	0.143	-0.098	-0.016	-0.239	-0.223	0.643	0.245	0.186	0.468	0.728	-0.200	1.000		
SW	-0.507	-0.493	-0.631	0.095	-0.591	0.499	-0.011	-0.090	0.116	0.189	-0.142	0.662	1.000	
SL/SW	0.865	0.574	0.818	-0.371	0.536	0.037	0.250	0.299	0.376	0.626	-0.157	0.356	-0.442	1.000

LL: leaf length, LEL: leaflet length, LEW: leaflet width, LEL/LEW: leaflet length/ leaflet width, PETL: petiole length, PED: pedicel length, PEL: petal length, PEW: petal width, FL: fruit length, FW: fruit width, FL/FW: fruit length/ fruit width, SL: seed length, SW: seed width, SL/SW: seed length/ seed width.

Table 5: Cluster analysis revealing relationship between ten *Cassia* species

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	0									
C2	5.069	0								
C3	1.57	4.319	0							
C4	2.556	4.804	2.049	0						
C5	2.224	3.382	1.741	2.179	0					
C6	3.459	3.38	2.611	2.344	1.436	0				
C7	2.404	3.388	1.818	2.268	0.24	1.475	0			
C8	3.213	2.934	2.297	2.611	1.296	1.279	1.156	0		
C9	2.874	5.087	2.749	0.883	2.708	2.843	2.879	3.064	0	
C10	0.624	4.801	1.649	2.136	1.874	3.1	2.054	2.884	2.644	0

C1: *Cassia abscondita* L., C2: *Cassia alata* L., C3: *Cassia auriculata* L., C4: *Cassia obtusifolia* L., C5: *Cassia occidentalis* L., C6: *Cassia simea* Lamk., C7: *Cassia sophera* L., C8: *Cassia surattensis* Burm.f.ssp glauca(Lam.)K.&S., C9: *Cassia tora* L., C10: *Cassia uniflora* Mill.

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