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A Study on the Seed Morphology of the Genus *Cassia* L. *sensu lato* in the Sudan*

Wail E. Abdalla, Gamal E. B. El Ghazali[1], Abdelgabbar N. Guma'a[2] and Hassan E. Khalid

Medicinal and Aromatic Plants Research Institute, National Centre for Research, Khartoum, Sudan

Abstract: Morphological characters of seeds from 23 *Cassia* L. *sensu lato* species from Sudan were examined with the aid of Stereo Microscope in order to clarify their taxonomic status. The seeds of all members of the genus *Senna* (with the exception of *S. bicapsularis*) were areolate, whereas the seeds of *Cassia sensu stricto* and *Chamaecrista* species were not areolate and the shapes of the latter two genera were ovate-elliptic and rhombic, respectively. The seeds are described, an indented identification key is presented, and the unique taxonomic position of *S. bicapsularis* is discussed. The results supported the division of the genus *Cassia* L. *sensu lato* into three allied genera (*Cassia sensu stricto, Chamaecrista* and *Senna*).

Key words: Seed morphology; *Cassia*; *Chamaecrista*; *Senna*; areolae; Caesalpiniodeae.

INTRODUCTION

The genus *Cassia* L. {Family: Fabaceae/ Leguminosae, subfamily: Caesalpinioideae (APG 2003)} is one of the largest genera of flowering plants. It occurs naturally in the tropics and subtropics (Pechsri and Boonkerd 2003). It is an important genus because of its various economical uses, especially for medicinal purposes. The laxative properties possessed by various species of the genus are well-known for a long time, and it is included in several pharmacopeias and studies (BHMA 1983). Taxonomically, some species are difficult to identify due

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[1] College of Science and Arts, Qassim University, Buraidah- Kingdom of Saudi Arabia
[2] Faculty of Education, University of Khartoum, Um Durman, Sudan

to the presence of morphological complexes. Accordingly, this genus was divided by some workers into three allied genera; namely, *Cassia* L. *sensu stricto*, *Chamaecrista* Moench and *Senna* Miller. However, some authors still place all species in a single genus, i.e. *Cassia* L. *sensu lato* (Pechsri and Boonkerd 2003).

A taxonomic revision of the genus *Cassia* L. *sensu lato* in Africa was made by Brenan (1958a, 1958b, 1967). Irwin and Barneby (1981, 1982), working on the taxonomy of *Cassia* L. in America, raised the genus to the level of sub-tribe and elevated previous subgenera to generic ranks, viz. *Senna* Mill. and *Chamaecrista* Moench, in addition to *Cassia sensu stricto*, under the tribe Cassieae Bronn ex Irwin and Barneby of Caesalpinioideae. The previous work was based mainly on the characteristics of the filaments and the presence or absence of bracteoles. The concept of Irwin and Barneby (1981, 1982) has also been followed by Lock (1988, 1989), Randell (1988, 1989, 1990) and Larsen and Hou (1996) in their works on the revision of sub-tribe Cassiinae Irwin and Barneby from Africa, Australia and Malaysia, respectively (Singh 2001), where the genus *Cassia sensu lato* was divided into three allied genera: *Cassia sensu stricto*, *Chamaecrista* and *Senna*.

Seed morphology, as a character for clarifying the taxonomic status of a taxon, was used by many workers, such as Newell and Hymowitz (1987), Gonzalez-Anders and Ortiz (1995) and Zhu (2007). Studies on seed morphology of the species belonging to the family Fabaceae/ Leguminosae include those of Bhandari *et al*. (1985), Butler (1988) and Kirkbride *et al*. (2003). In particular, studies on *Cassia sensu lato* seed morphology were carried out by workers like Bragg (1985) and Bravo *et al.* (1986).

In Sudan, there are 23 species belonging to the genus *Cassia* L. *sensu lato*, 16 of which are indigenous and 7 are exotic (Andrews 1952; El Amin 1981; Abdalla 2008). According to the latest classification of the genus (Irwin and Barneby 1982), members of *Cassia* L. *sensu lato* in Sudan are distributed between the following allied genera: *Cassia sensu stricto* (8 species), *Chamaecrista* (3 species) and *Senna* (12 species). In a recent taxonomic revision of the genus *Cassia* L. *sensu lato* in the Sudan

(Abdalla 2008), various characters were examined to justify or otherwise the division of the genus into three allied genera.

The present study aimed to use seed morphology as a primary character to reveal the taxonomic status of the genus *Cassia* L. *sensu lato* in the Sudan and to support or otherwise the present taxonomic treatments of the genus. The study will also provide visual as well as descriptive morphological data of seeds which will contribute positively to Sudanese medicinal plants' monographs.

MATERIALS AND METHODS

Fresh plants {collected mainly from Khartoum State, west Kordofan (El Fula and Babanosa) and Blue Nile State (Dinder)} as well as herbarium specimens deposited at various Sudanese herbaria were used to study the seeds of the various members of the genus *Cassia* L. *sensu lato* in the Sudan. Fully mature seeds belonging to 23 different species (including 16 indigenous and 7 exotic) were examined. Seed morphological characters were examined under Adac M6C-10 Stereo microscope and photographed with Sony Cyber-shot 7.2 mega pixels digital camera attached to the same microscope.

Herbarium specimens for each species under investigation were prepared and deposited at the Herbarium of the Medicinal and Aromatic Plants Research Institute, National Centre for Research, Khartoum.

RESULTS

An indented identification key was constructed, followed by a brief description of seeds from all allied genera and species studied.

Identification key for the allied genera and species of *Cassia* L. *sensu lato* using seed morphological characters:

A.	Seeds areolate ……..……..……..……	***Senna***
	B.	Seeds more or less deltoid-rhombic, areolae displaced to the hilum end ……..…….. *S. alata*
	BB.	Seeds circular to ovate-oblong, areolae not displaced:

		C.	Seeds circular ……..…… *S. singueana*						
		CC	Seeds ovate-oblong:						
			D.	Seeds reticulate-rugose:					
				E.	Seeds oblong……..…….. *S. alexandrina*				
				EE.	Seeds ovate……..…….. *S. italica*				
			DD	Seeds smooth:					
				F.	Seeds with linear areolae …….. *S. obtusifolia*				
				FF.	Seeds with oblong areolae:				
					G.	Seeds ovate-suborbicular:			
						H.	Testae minutely pimpled; areolae c. 2.5 x 1.5 mm ..... *S. occidentalis*		
						HH	Testae smooth:		
							I.	Areolae c. 1.5 x 1 mm …… ……*S.* sp. aff. *occidentalis*	
							II.	Areolae c. 4-5 x 2.5 mm…… ……..…. *S. petersiana*	
					GG	Seeds oblong:			
						J.	Seeds truncate at both ends . *S. siamea*		
						JJ.	Seeds apiculate at hilum end:		
							K.	Seeds tomentose; areolae small (less than 1 x 0.3 mm), situated below the middle on both faces ……. *S. holosericea*	
							KK	Seeds glabrous; areolae relatively large (greater than 2.4 x 1 mm), situated on the middle of both faces:	
								L.	Seeds' bases truncate, margins straight …….. ……*S. didymobotrya*

								LL	Seeds' bases rounded, margins more or less convex:	
									M.	Seeds' apices abruptly narrowed towards hilum ends …. ……. …*S. auriculata*
									MM	Seeds' apices gradually narrowed towards hilum ends ……... ..*S. surattensis*
AA	Seeds not areolate:									
	N.	Seeds ovate-elliptic, globular or compressed …..…….. ***Cassia***								
		O.	Seeds embedded in pulp ...…..……..… *C. thyrsoidea*							
		OO	Seeds not embedded in pulp:							
			P.	Seeds globular not compressed:						
				Q.	Seeds smooth ..……..…….... *C. fistula*					
				QQ	Seeds with slight reticulate cracking:					
					R.	Seeds biconcave to plano- or concavo-convex …….. *C. grandis*				
					RR.	Seeds ellipsoid or ovoid-ellipsoid:				
						S.	Seeds broadly ovate, 5-7 x 4-6 x 3-4 mm ……. *C. javanica* subsp. *nodosa*			
						SS.	Seeds ellipsoid or ovoid-ellipsoid, 8-9 x 4.5-7 x 2.5-4 mm … *C. sieberiana*			
			PP	Seeds compressed:						
				T.	Seeds ovoid or obovoid, slightly compressed:					
					U.	Seeds ovoid ……..*C. arereh*				
					UU.	Seeds obovoid ..…….…. *C. mannii*				
				TT.	Seeds elliptic to sub-reniform, clearly compressed …….. *Senna bicapsularis*					

	NN.	Seeds rhombic or sub-rhombic, clearly compressed ….***Chamaecrista***			
			V.	Seeds with faint dots on both surfaces, black glossy ……..……..... *C. absus*	
			VV	Seeds smooth, brown:	
				W.	Seeds rhombic or oblong, 2-3 x 1-2 mm ……. ……...… ……...….. *C. mimosoides*
				WW.	Seeds obovate or rhombic, 2.5-4 x 1.5-2.5 mm ……..... *C. nigricans*

A brief description of the seed morphology of *Cassia* L. *sensu lato* species in the Sudan

1- *Cassia arereh* Del.: Seed ovoid, slightly compressed, c. 10 x 7 mm, brown, without areole.

2- *C. fistula* L.: Seed ovate, 8-10 x 6-8 mm, with a shallow longitudinal depression on both faces, glossy brown, smooth, without areole.

3- *C. grandis* L.f.: Seed elliptic, biconcave to plano- or concavo-convex, 7- 15 x 5-10 mm, reticulately veined, smooth, brown, without areole.

4- *C. javanica* L. subsp. *nodosa* (Roxb.) K. & S. Larsen: Seed broadly ovate, 5-7 x 4-6 x 3-4 mm, with a shallow longitudinal depression on both faces, glossy brown, with slight reticulate cracking, without areole.

5- *C. mannii* Oliv.: Seeds flattened, obovoid, compressed, 9-10 x 6 x 3-4 mm, brown, transversely cracked.

6- *C. sieberiana* DC.: Seed ellipsoid or ovoid-ellipsoid, 8-9 x 4.5-7.0 x 2.5- 4.0 mm, brown, smooth with slight reticulate cracking, without areole.

7- *C. thyrsoidea* Brenan: Seeds embedded in pulp, ovate-elliptic, 6-7 x 5- 6 mm, brown.

8- *Chamaecrista absus* (L.) Irwin & Barneby: Seed sub-rhombic, flattish, 4.0-5.5 x 3.5-4.5 mm, with faint dots on both surfaces, black, glossy, without areole.

9- *C. mimosoides* (L.) Greene: Seed rhombic or oblong, narrowed at hilum end, 2-3 x 1-2 mm, brown, without areole.

10- ***C. nigricans*** **(Vahl) Greene:** Seed obovate or rhombic, narrowed at hilum end, 2.5-4.0 x 1.5-2.5 mm, brown, without areole.

11- ***Senna alata*** **(L.) Roxb.:** Seed flattened, more or less deltoid-rhombic, acuminate at the hilum end, with a longitudinal ridge along each face, 4-8 x 2-5 x 1.0-2.5 mm, areole 2-3 mm long, displaced on the edge near the hilum.

12- ***S. alexandrina*** **Mill.:** Seed more or less compressed, oblong, apiculate near hilum, 5-7 x 3.5-4.0 x 1.5-2.0 mm, reticulate or rugose, with a small areole; 1-2 x 0.5-0.7 mm, on each face.

13- ***S. auriculata*** **(L.) Roxb.:** Seed compressed, ovate-oblong, 4-9 x 3-5 mm, purplish-brown, with a distinct areole; 3.0 x 0.5 mm, on each face.

14- ***S. bicapsularis*** **(L.) Roxb.:** Seeds many, olive brown, compressed, elliptic to subreniform, 5-6 x 3.5-4.5 mm; areole absent.

15- ***S. didymobotrya*** **(Fresen.) Irwin & Barneby:** Seed more or less compressed, oblong, apiculate at hilum end, 8-9 x 4-5 x 2-3 mm, with an oblong areole; 4.0 x 1.5 mm, in centre of each face.

16- ***S. holosericea*** **(Fresen.) Greuter:** Seeds 5.0-5.5 x 3-4 mm, obovate-oblong, emarginated at broader end, narrowed towards hilum, smooth, tomentose, grey-white; areole c. 0.7 x 0.2 mm, oblong, situated below the middle on both faces.

17- ***S. italica*** **Mill.:** Seed more or less compressed, ovate, apiculate near hilum, 5-7 x 2-4 x 1.0-1.25 mm, reticulate-rugose, with a small

18- ***S. obtusifolia*** **(L.) Irwin & Barneby:** Seed more or less rhombic or ovoid, 4.5-6.5 x 2-4 mm, brown; areole linear, very narrow, 3.0-4.5 x 0.3-0.5 mm.

19a- ***S. occidentalis*** **(L.) Link:** Seed compressed, ovate-suborbicular, 4-5 x 3.5-4.5 mm, grey-brown; testa minutely pimpled, with an elliptic areole; 2.5 x 1.5 mm, on each face.

19b- ***S.*** **sp. aff.** ***occidentalis*****:** Seed slightly compressed, ovate-suborbicular, sometimes triangular, 3.0-3.5 x 2.5-3.0 mm, grey-brown; testa smooth, with an elliptic areole; 1.5 x 1.0 mm, on each face.

20- *S. petersiana* (Bolle) Lock: Seeds many, somewhat compressed, ovoid or suborbicular, 5-7 x 4-6 mm, brown, with an olive areole coloured, c. 4-5 x 2.5 mm on each face or marginal.

21- *S. siamea* (Lam.) Irwin & Barneby: Seed oblong, flat, truncate at both ends, 7-10 x 4-6 mm, light brown; areole elliptic, 2-3 mm long.

22- *S. singueana* (Del.) Lock: Seed circular and flattened when mature and irregular in shape when immature, 4-6 mm in diameter, dull brown, with a small areole; 2.0-2.5 x 1.0-1.5 mm, on each face.

23- *S. surattensis* (Burm.f.) Irwin & Barneby: Seed oblong, narrowed towards the hilum, 5-7 x 2.5-4.0 x 1.0-1.5 mm, shiny black; areole oblong, 2.5-4.0 x 1.0-1.6 mm, in centre of each face.

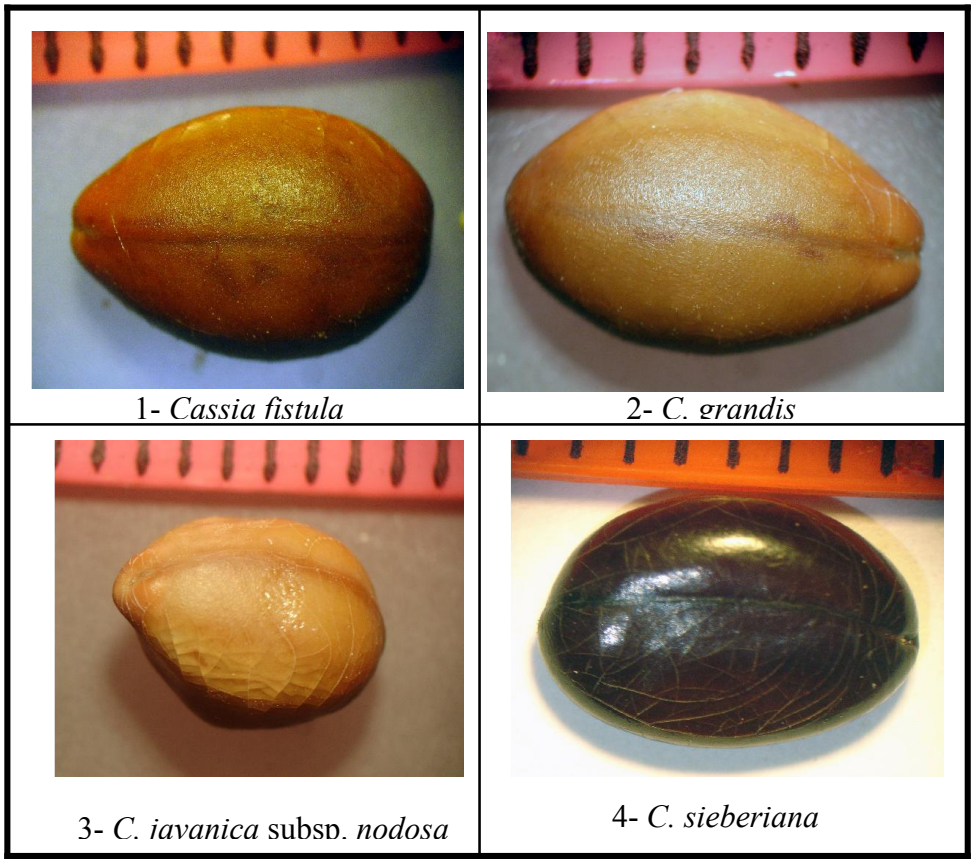
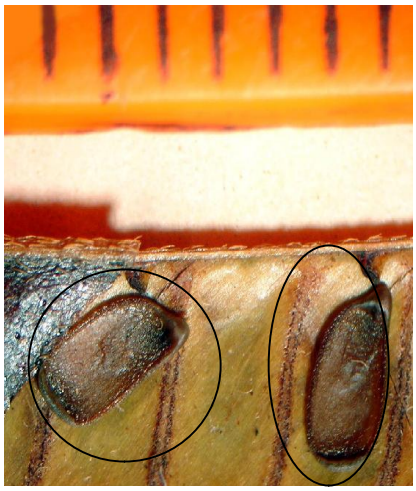


Fig.1. Seed morphology of some *Cassia* L. *sensu stricto* species in the Sudan

1- *Chamaecrista absus*



2- *C. mimosoides*

3- *C. nigricans*

Fig.2. Seed morphology of *Chamaecrista* species in the Sudan

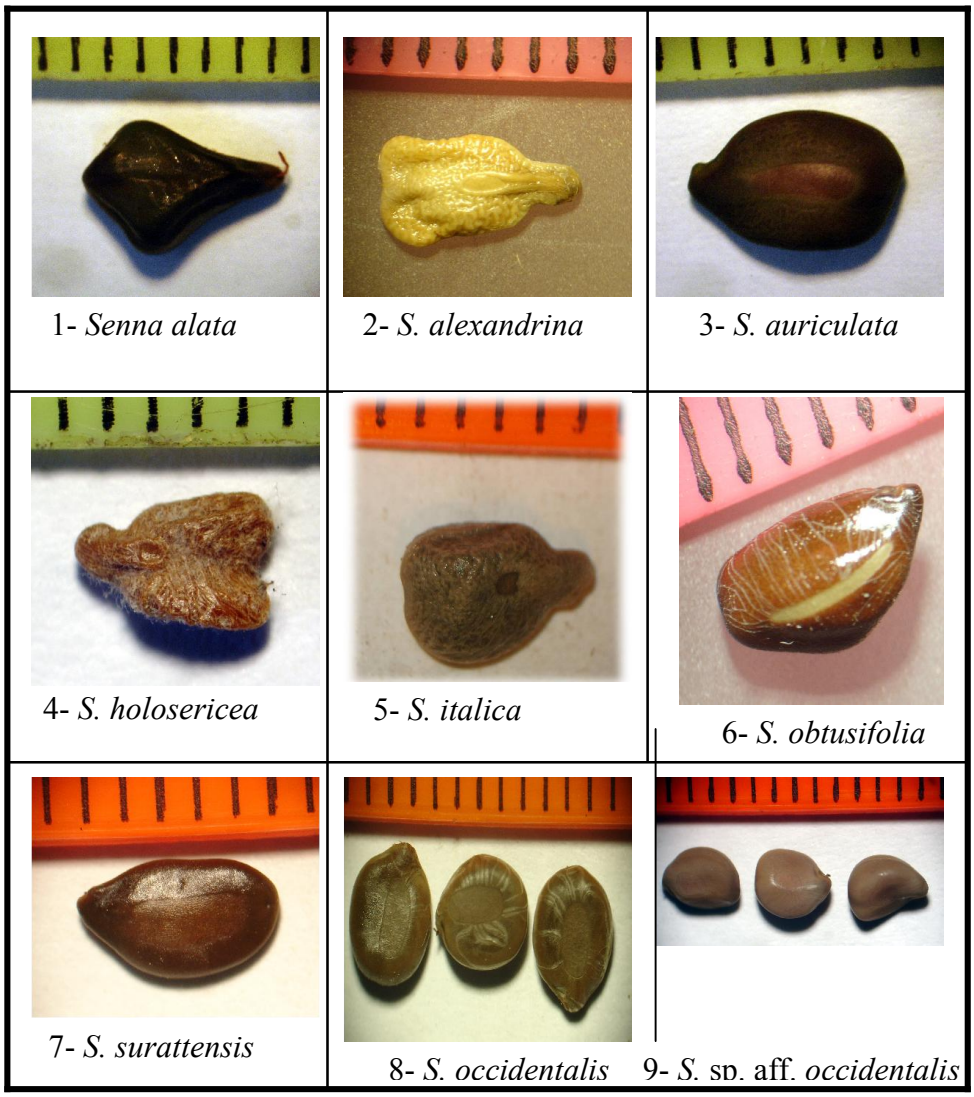


Fig.3. Seed morphology of some *Senna* species in the Sudan

DISCUSSION

The present study on the seed morphology of various members of the genus *Cassia* L. *sensu lato* in the Sudan supported the latest taxonomic treatment of the genus which was made by Irwin and Barneby (1982). On the basis of seed morphology, members of *Cassia sensu lato* were divided into three main groups coinciding with three allied genera; namely, *Cassia sensu stricto, Chamaecrista* and *Senna*. Among the various features of seed morphology, the presence/ absence of areolae was considered an important primary diagnostic character to distinguish between the allied genera of the genus *Cassia* L. *sensu lato*. Areolate pattern, as a unique seed morphological character, was previously used by Siddiqui (1993) and Sebastian *et al*. (2002) to distinguish between two groups within the genus *Euphrasia* L. (Scrophulariaceae) and to identify different clones of *Hevea brasiliensis* Muell. Arg. (Euphorbiaceae), respectively. Other morphological characters used to distinguish the species were seed shape, texture and colour.

In the material examined, the presence of areolae was not clearly recognized in all members of the genera *Cassia sensu stricto* and *Chamaecrista*, whereas it was quite distinct in the genus *Senna* (with the exception of *S. bicapsularis*). Using only seed morphological characters, it seems that the latter species (*S. bicapsularis*) is more related to the genera *Cassia sensu stricto* and *Chamaecrista* than to members of its own genus. Further studies on *S. bicapsularis* are needed to elucidate its affinity within the genus *Cassia sensu lato*.

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الشكل الظاهري لبذور الكاسيا *Cassia* L. *sensu lato* في السودان

وائل الصادق عبد الله و جمال الطيب بشرى الغزالي[1]
و عبد الجبار ناصر جمعة[2] و حسن السبكي خالد

معهد أبحاث النباتات الطبية والعطرية- المركز القومي للبحوث، الخرطوم- السودان

موجز البحث: درست الصفات المورفولوجية لبذور 23 نوع من جنس الكاسيا *Cassia* L. *sensu lato* في السودان بإستخدام مجهر مجسم وذلك لتوضيح وضعها التصنيفي. إحتوت بذور كل أفراد جنس سنا *Senna* (بإستثناء *S. bicapsularis*) على هالة ، بينما لم تحتوي بذور الجنسين كاميكريستا *Chamaecrista* و كاسيا *Cassia sensu stricto* على هالات، وتراوحت أشكال بذور الجنسين الأخيرين بين بيضاوي - إهليلجي و معين، على التوالي. تم وصف البذور وعمل مفتاح تعريفي مسنن، كما نوقش الوضع التصنيفي المميز للنوع *S. bicapsularis* . أيدت النتائج تقسيم جنس الكاسيا *Cassia sensu lato* إلى ثلاثة أجناس مرتبطة (*Cassia sensu stricto, Chamaecrista* and *Senna*) .

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[1] كلية العلوم والآداب- جامعة القصيم، بريدة- المملكة العربية السعودية.
[2] كلية التربية- جامعة الخرطوم، أم درمان - السودان.