Evaluation of exomorphic characters of some Indian species of *Cassia* occuring in and around kolkata, west bengal with an overview on cytotaxonomy.

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ABSTRACT: The genus *Cassia* exhibits a great deal of diversity and is taxonomically complex; there has been considerable divergence of opinion concerning the delimitation and taxonomic status of this group of plant. In the present study, morphological characters of the taxa has been used for the construction of keys for the easy identification and the Cytological features of the genus *Cassia* were also reviewed.

Key words: Cytotaxonomy, *Cassia*, Chromosome number, Cytological features.

INTRODUCTION:--

*Cassia* L. is one of the twenty-five largest genera of dicotyledonous plants in the world (Acharya Laxmikanta and Chandra Panda Pratap). The taxa have expanded greatly from the Miocene onwards and the versatility of the taxa enhances their great economic importance which is increasing as human pressure demands more effective use of marginal lands. In the long term a much wider and more subtle use of immense natural variation may be harnessed to fix nitrogen, conserve soil, provide timber, fuel, pesticides and amenity value, as well as more carbohydrate, proteins and oils. Besides their immense floricultural values, these find effective utilization in indigenous systems of medicine. The species under this taxon have wide variability in habit ranging from tree to delicate annual herbs. Despite several studies by taxonomists, either on the whole family Caesalpiniaceae in restricted area of certain genera throughout the world there is still great deal of taxonomic work to be done at the level of genus and tribe.

The plants of *Cassia* L. are used as fodder, purgatives, timber and medicine (Tomlinson, 1981; Tiwari, 1983). The genus *Cassia* of the family Leguminosae represents one of the largest and more diverse group of flowering plants including herbs to trees that are well-known for their beauty and utility. The genus *Cassia* exhibits a great deal of diversity and is taxonomically complex; there has been considerable divergence of opinion concerning the delimitation and taxonomic status of this group of plants.

The taxonomy and nomenclature of *Cassia* L. species are quite complex and intriguing. Bentham(1871) divided the genus *Cassia* into three genera and nine sections. Britton and Rose(1930) splitted the genus *Cassia* into twenty-eight genera. Recently Irwin and Barneby(1982) splitted the genus *Cassia* L. into three subgenera; *Cassia* L., *Senna* Mill and *Chamaecrista* Moench. Irwin and Baneby(1981-1982) realizing diversity and complexity and proposed an improved classification proposing new delimitation based on persistent suit of characters. They have raised the genus *Cassia* L. to the levels of subtribe (Cassiinae) and raised the subgenera *Senna* Mill. and *C.* Moench to genetic level.

Structural changes in DNA, that is, translocation, deletion, inversion mutation have been able to change the genomic constitution of species. In decades, these changes in the genome of species, separate the particular species from their ancestors. To assess these
changes, parameters based on morphological characters are not sufficient. Now it is possible
to single out differences on the basis of molecular markers, which is authentic and less
affected by environmental factors. Hence characterization of species at the genetic level
supplemented efficient conservation, maintenance and utilization of the existing genetic
diversity

The genus *Cassia* constitutes taxonomically complex group of plants. There is great
potential for *Cassia* utilization as a dietary supplement or as a protein bank and this explains
the interest of other group in this genus. There is still a gap in the cytogenetic data of this
genus since most of the available information is restricted to chromosome counts of the
species. The main reasons for this scarcity of information include small chromosome size and
heavy cytoplasmic contents, which makes chromosome counting difficult, and lack of a
defined taxonomy, until recently

**REVIEW OF LITERATURE:**

It is remarkable to mention that the family Caesalpinioideae has attracted an array of workers
from various disciplines e.g. anatomy (Tripathy and Mondal, 2012; Kanak Sahai, 2001); Ramadan and Ibrahim, 2013),
molecular (Tripathi and Goswami, 2011) palynology (Aftab and Parveen, 2006; Mohammad Quadeer Butt, 1989);
phytochemical (Shailesh M. Kewatkar, 2012), pharmacological (Sumi S. and Oommen P.Saj; Mohammed
and Aboki et al, 2012). It is thus evident from perusal of above literature that no work has
been done on statistical analysis of some morphological characters of some members of the
family of Caesalpinioideae.

**MATERIALS AND METHODS**

In the present investigation the following species of taxa were taken:

1. *Cassia fistula* L.
2. *Cassia glauca* Lam.
3. *Cassia javanica* L.
4. *Cassia occidentalis* L.
5. *Cassia siamea* Lamk.
6. *Cassia sophera* L.

Various localities were exposed for collection of plant materials during the course of
investigation. For collection of specimens and respective field data, several attempts were
made in different seasons of each year. In each collection trip, assistance of local people was
sought. During the field trip, 3 to 5 samples of each species were taken. The place of
collection of plants were carefully marked in such a manner that these could be easily spotted
out during flowering and fruiting time.
After collection, these specimens were pressed, preserved and mounted on herbarium sheets following the standard and modern herbarium techniques (Jain and Rao, 1977). For identification purpose, collected specimens were matched with the specimens at the Central National Herbarium (CAL) and the Calcutta University Herbarium (CUH).

During floristic survey fruits and or seeds were procured from different taxa as and when became available. After harvesting, fruits and or seeds were air-dried at room temperature for 2-3 weeks. The clean seeds were kept in glass vials with proper labelling for study. Seeds for each taxa were air-dried for 2 weeks and weighed individually using an electronic balance.

The plant parts were figured, characterized from fresh specimens immediately after collection and subsequently scanned from dry specimens. Colour photographs were taken for each specimen. In this case close-up views were taken mostly with scale. Out of the collections, a comprehensive list of species was prepared. Then search of relevant literature including recent ones for determining correct names of taxa was followed. In the systematic enumeration of the taxa, the arrangement of species were considered in an alphabetical order for the sake of convenience. For morphological diagnoses, the characters of stem, leaf, stipules, bracts, nectaries, stamen, anther, ovary, style, stigma, fruit and seed were taken into consideration. In mentioning the locality under “specimen examined”, the collector’s name, field number and name of the sector were used. Out of the several specimens examined, only few have been cited.

Detailed artificial keys for the species were developed as in floristic studies for the identification of investigated taxa using diagnostic morphological characters (Table 1). In preparing these keys, important distinguishing features and also some additional characters were used to ensure the identity of a taxon. After describing the plants, the traits were coded as binary alternatives. Diagnostic characters were scored for cluster analysis and phenogram was prepared using UPGMA (Unweighted Pair-Group method for Arithmetic Average) method with the assistance of STATISTICA program (StatSoft, 1995).

With regards to cytological data on the investigated taxa, all works are based on review work.

**DIAGNOSES OF PLANTS**


**Local name**—Sundaraj, Amaltas

It is a moderate sized deciduous tree, perennial, erect around 15-20 m tall. **Stem**—It is 12-15 ft in girth, brownish grey in colour. **Leaf**—Pinnately compound, paripinnate, about 6.5-12.5 cm long and 5.5-6.5 cm wide, stipulate, stipules deltoid, acute 1-2 mm long, caduceus; leaflets 6 pairs, oppositely arranged; margin entire; lamina ovate; basal leaves are smaller and wide ovate while upper leaves are larger and ovate; Base and apex acute; primary vein 1, secondary veins 12-24 pairs per leaflet, mostly alternate, more prominent on abaxial surface. **Inflorescence**—Racemose corymb; **Flower**—Zygomorphic, bracteates, pentamorous and complete; pedicel green, sparcely pubescent, 6 cm long; Sepals pubescent, greenish-yellow,
connate at the base, pentamerous, ovate, 0.4-1.2 cm long and 0.3-0.6 cm wide; petals brilliant-yellow, 2.1cm long, pentamerous, elliptic, obovate, distinctly veined. **Androecium**-10,3 longest much curled and bear large oblong anthers, 4 medium ones quite straight, 3 remaining ones sterile. **Gynoecium**-Ovary slender, thinly appressed, hairy; style sturdy; stigma punctiform. **Fruit**-Pods terete, glabrous, 30-60 cm long, indehiscent, green when young and black after ripening with 40-100 seeds, embedded in a dark coloured sweetish pulp and separated by transverse partitions. (Pl.1a)

**Flowering**- March to May; **Fruiting**- October to April

**Ecology**-Very common in deciduous forest, also planted in roadsides and in gardens.

**Distribution**-Throughout India, Sri lanka, Malaysia, China, Egypt and other parts of Tropics.

**Specimen examined**- Sanyal 1, Bethune college campus; Sanyal 10, Saltlake, EC Block;

**Uses**- 1.In relieving the symptoms of asthma, leprosy, ringworm, fever and heart related diseases.

2. As laxative and in treatment of constipation.

3. Root used in treating common cold.

4. Leaf relieves in swelling and pain. Also useful in reducing irritation in the skin.

5. Fruit and bark of stem helps in blood purification.

**Cassia glauca** Lam.

It is a glabrous, evergreen, fast-growing shrub to small tree about 2-5m tall. **Leaf**-Bipinnately compound, stipules caduceus, linear; petioles 3 mm, leaflets 4-6 pairs, abaxially white, adaxially greenish, elliptic; base cuneate; apex inconspicuously emarginated. Nectar glands present between first, second and third pairs of leaflets. **Inflorescence**- Axillary raceme; **Flower**-Bright-yellow, 1-1.3cm long; bpedicel greenish, 2cm long; sepals pubescent, greenish-yellow, unequal(outer 2 sub-orbicular and inner 3 obovate), petals bright-yellow, ovate-obovate, veined, clawed; 3 longer(1.7cm length and 1.2cm width)and 2 shorter(1.4cm length and 0.9cm width). **Androecium**-Stamens 10, all fertile, filaments thick, anthers subequal, opening by short apical slits. **Gynoecium**- Style greenish, glabrous, 2.3cm long, ovary hairy. **Fruit**-Pendulous pod, glossy, straight, strap-shaped, with slender beak on top valves.Seeds 20-30, pale-brown, shiny and oblong-elliptic. . (Pl.1b)

**Flowering and Fruiting**-august - october

**Distribution**-It is capable of growing on all kinds of soil including coastal lands.

**Specimen examined**-Sanyal 4 tala park, Sanyal 7 Saltlake EE block
Uses- 1. Bark and leaves used in treatment of diabetes and gonorrhoea.

2. Leaves are pounded in sugar and milk used for blennorrhagia.

3. Phytochemical study of stem has indicated the presence of chrysophenol, physcion, stearic acid.

4. Aerial parts are used as CNS depressant and as diuretic.

5. Seeds have antimalarial and purgative properties.

6. This plant is a good pollution tolerant and reduces chemical pollutants in the atmosphere.


Local name-java ki rani

It is a small deciduous tree. Stem- Not more than 15m. Branches numerous, spreading, glabrous. Leaf- bifarious; rachis 20-30cm long, stipules lunate, caducous, lower horn lanceolate, upper horn broader, rounded or emarginated; leaflets 5-15 pairs, short petiolated, oblong to elliptic, rounded to obtuse at apex, broadly rounded at base, dull below, appressed pubescent, pentamerous, softly hairy, 3-5cm long and 1-1.5cm wide. Inflorescence-Racemes erect, arising laterally from branches, forming a corymb, 5-16cm long; peduncle 2-3cm long.

Flower- Bracteate, complete, bracts ovate 1-1.5cm long, pedicels 3-5cm long. Bracteoles linear-oblong, 4-5mm long; sepals pentamerous, ovate, dark red to reddish-brown, 0.7-1cm long; petals first bright-rose to pink, later dark red, finally pale, obovate, veined, shortly clawed. Androecium- Stamens 10, upper 3 reduced to staminodes; remaining 7 perfect, of which 3 longer with 1.5-2cm long filament and 3.5-4mm long anthers, other 4 shorter 0.8-1cm long; anthers opening by basal pores. Gynoeccium- Ovary pubescent, recurved. Fruit- Pods terete, glabrous, black, indehiscent, 20-60cm long and 1-2cm diameter. Seeds 50-80, brown, flat, glossy, orbicular, embedded in a flat disc.(Pl.1c)

Flowering-March to May; Fruiting-August to February

Ecology- Common; planted in gardens, parks, forests, roadsides etc.

Distribution-Major parts of India. Native of Malaysia, Indonesia to Phillipines, now widespread throughout the tropics.

Specimen examined- Sanyal 6, Salt lake IB block; Sanyal 7, Saltlake CC block

Uses-The plant is grown as an ornamental for its beautiful pink flowers.

Senna occidentalis (L) Roxb., Fl.Ind.2:343.1832

Local name- Kasondi

This is a common undershrub found near habitations, along roadsides as well as wastelands. They are erect, diffuse, glabrous, suffrutescent upto 1.5-2cm tall, mostly annuals, sometimes they are biennials. **Stem**- Greenish at the top and greyish brown at the base with glabrous surface, angular,0.5cm in diameter. **Leaf**- Pinnately compound, paripinnate, stipulate, stipules ovate, 4-6.5mm, acuminate, caduceus; rachis glabrous; leaflets 3-5 pairs, opposite, petiolate, top pair being the largest(11.4cm long and 3.8cm wide)broadly lanceolate to ovate or narrowly to broadly elliptic, apex acute, base rounded, glabrous. A petiolar nectary (solitary naked) found immediately above the pulvinus, dark red in colour. Margin entire, apex mostly attenuate (sometimes acuminate). Primary vein 1, secondary veins are 7-14 pairs per leaf. **Inflorescence**- Racemes short, peduncled, axillary and terminal, sometimes panicled, few flowered; peduncle 1-2cm long. **Flower**- Bracteate, 0.7cm long, ovate, oblique, acuminate, caduceus, complete, yellow; sepals greenish-yellow, sparsely pubescent, connate at the base, pentamemorous, unequal, obtuse, oblong, about 0.4-1.2cm long and 0.3-0.6cm wide, mucronate, slightly veined, about 1.5cm long and 1cm wide; petals subequal, bright-yellow with violet veins, oblong-obovate, shortly clawed; pedicel 1-1.5cm long. **Androecium**- Stamens 10, lower 3 (1.2cm) longer than 4 lateral stamens(0.7mm), 3 staminodes(0.5mm) present, filament greenish-yellow, anther brownish-yellow, fertile anthers opening by terminal pores. **Gynoecium**- Ovary tomentose, style and stigma are greenish upto 1.3cm long, stigma is dark-brown. **Fruit**- Flat pod; pods slightly falcate, compressed with transverse septation, sutures thick, dark grey in colour, 8.4-13.6cm long and 4.3cm wide. Seeds 20-30, ovoid, compressed, 6-6.5mm long, 5mm broad rounded at tip, subacute at base, smooth, hard, shining, pale brown. . (Pl.1d)

**Flowering and Fruiting**- October to March

**Distribution**- Throughout India, native of South America, now pantropical.

**Ecology**- Common near habitations, grassy localities, agricultural fields, forest clearings. Also found along roadsides and near wastelands.

**Specimen examined**- Sanyal 2 Bethune College campus, Sanyal 2 tala park, Sanyal 6 Saltlake DD block

**Uses** - 1. Leaves and pods administered in Ayurvedic systems of medicine as infusion and considered a great tonic.

2. The seed is bitter and has tonic, febrifugal and purgative properties. It is considered to be a blood tonic and excellent diuretic.

3. The seeds are useful in cough, whooping cough, convulsions and in heart diseases.

4. Seed powder externally used in cutaneous diseases and eruptions.

Senna sumtran (DC.) Roxb., Fl. Ind. 2:347.1832

It is a medium-sized evergreen tree growing up to 18-30m tall. **Stem** - Greenish at the top and brownish at the bottom, young branches striate, finely pubescent. **Leaf** - Pinnately compound, paripinnate, about 15-30cm long and 2.5cm wide, without glands; stipules subulate, caduceus 1mm long; petiole 1.5-3cm long, oblong-ovate, lower surface pilose, upper surface glabrous to hairy; 10 pairs of leaflets oppositely arranged, elliptic-oblong, base obtuse, apex acute with short mucronate tip, margin entire, subcoriaceous, glaucous, finely pubescent beneath, shortly veined. Primary vein 1, 12-24 pairs of secondary veins per leaflet, alternate, more prominent on abaxial surface. **Inflorescence** - Racemes corymbose forming a crowded terminal 15-30cm long panicle; peduncle 5-7cm long; **Flower** - Bracteate, bracts obovate, appendiculate on back, 5-6mm long. Pedicels 2-3mm long, grey-pubescent. Bracteole absent; sepal ovate, concave, hairy on outside, connate at the base, pentamorous, elliptic, unequal; outer 2 smaller, 0.5-0.8cm long; inner 3 larger, 7-9mm long; petals bright yellow, elliptic or orbicular, upper petal shortly clawed. **Androecium** - Stamens 10, unequal, upper 3 reduced to staminodes, 2-4mm long; remaining 7 perfect of which lower 2-3 larger with 0.9-1cm long filaments and 6-7mm long anthers, one median and other 3-4 with 2-4mm long filaments and 5-6mm long anthers; anthers opening by apical pores. **Gynoecium** - Ovary finely pubescent. **Fruit** - Pods flat, nearly straight, strap-shaped, long stipitate, dehiscent, longitudinally waved with raised sutures, 15-25cm long and 1.5cm wide. Seeds 20-30, flat, bean-shaped, brown, 1-1.5x0.5-0.6cm. (Pl.1d)

**Flowering** - September to December; **Fruiting** - January to June.

**Ecology** - Very common; planted along roadsides, in wastelands for afforestation, also self-grown.

**Distribution** - Throughout India. Native of North-East Asia, widely cultivated in Tropics.

**Specimen examined** - Sanyal 4, Bethune College campus, Sanyal 6 Saltlake EC block

**Uses** - 1. Fruits and roots are used to destroy intestinal worms and control convulsions in children.

2. Roots treat fever while heartwood act as laxative.

3. Used to treat gall problems.

4. Bark works against haemorrhoids.


Senna purpurea Roxb. Fl. IND. 2:342.1832
Senna esculenta Roxb., l.c.346

Senna sophera(L.) Roxb., l.c 347

Local name- Bas-ki-kasunda

It is a common herbaceous annual occurring as a weed. It is a shrub, glabrous about 1-3cm in height. Stem- Glabrous, greenish at top and brownish at base. Leaf- Pinnately compound, paripinnate, stipulate, stipules ovate, caduceus, 6mm long, pulvinus present. Petiolar nectaries present at the base. Leaflets in 8 pairs, arranged oppositely, 3.2cm long and 1.2cm wide, ovate-oblong to narrowly lanceolate, margin entire, base rounded, apex acute. Petioles 1.5cm long, glabrous. Primary vein 1, Lateral veins 8-12 pairs per leaflet. Inflorescence- In short axillary and terminal few flowered panicles. Flower- Bracteate, bracts ovate-lanceolate, 4.5-5mm long, peduncle 1-2cm long, pedicels 1-1.5cm long. Bracteoles absent. Sepals shortly pubescent, greenish-yellow, connate at the base, about 0.6cm long and 0.4cm wide, pentamorous and lanceolate; petals brilliant-yellow, obovate, shortly clawed. Androecium- Stamens 10, upper 3-4 reduced to staminodes, 2-2.5mm long, remaining 6-7 perfect of which lower 2-3 larger with 5-7mm long filament and 4-7mm long anthers; anthers opening by apical pores. Gynoecium- Ovary flattened, finely pubescent; style terminal, 1cm long, light green; stigma slightly swollen, dark brown, 0.1cm long. Fruit- Pods swollen, straight or slightly curved, glabrous, 8-10*6-10mm. Seeds 30-40, ovoid, compressed, 3.5-4mm long. (Pl.1e)

Flowering and Fruiting- August to December

Ecology- Very common in waste places, roadsides, along railway tracks, gardens, forest lands.

Distribution- Throughout India, pantropical.

Specimen examined- Sanyal 5, Belghoria; Sanyal 11, Maniktala; Sanyal 12, Maniktala

Uses- 1. Root bark used in preparation of medicine (Mother tincture).
2. It acts as a expectorant and bronchodilator on skin. Used as an antiseptic.
3. It is used to cure cough, constipation, ringworm; rheumatic troubles and worm infestation.
4. Root is considered as an expectorant; bark leaves and seeds are cathartic; leaves are

Key to the investigated taxa:

1(a)Pods indehiscent, woody, terete; stamens 10, all fertile, the 3-2 lowest larger than the rest:-

2(a)Leaflets 4-8 pairs; inflorescence pendulous, flowers bright-yellow, in long raceme, bracts minute deciduous…………………………………………………C. fistula
2(b) Leaflets 8-20 pairs; inflorescence erect, flowers pink, in paired lateral racemes, bracts large, persistent................................. C. javanica

1(b) Pods dehiscent, compressed, rarely turgid and sub-terete:-

3(a) Foliar glands absent; stamens 10, only 7 perfect of which 2-3 lower larger, upper 3 reduced to staminodes, a tree..........................C. siamea

3(b) Foliar glands present; bracts ovate, seeds ovoid-compressed or oblong-elliptic.

4(a) Gland near base of petiole:-

5(a) Gland ovoid, just above base of petiole. Leaflets ovate or ovate-oblong......................... C. occidentalis

5(b) Gland sub-acute, 0.5-1cm above base of petiole. Leaflets oblong-lanceolate.................C. sophera

4(b) Gland between lowest pair of leaflets, Leaflets 4 pairs or more, stamens 10, all perfect, pods flat.................................C. glauca

Table 1: Morphological characters of the studied species of Cassia

<table>
<thead>
<tr>
<th>CHARACTERS</th>
<th>C. fistula</th>
<th>C. glauca</th>
<th>C. sophera</th>
<th>C. occidentalis</th>
<th>C. siamea</th>
<th>C. javanica</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habit</td>
<td>tree</td>
<td>tree</td>
<td>shrub</td>
<td>undershrub</td>
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<td>Phyllotaxy</td>
<td>alternate</td>
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<tr>
<td>Lamina shape</td>
<td>ovate</td>
<td>elliptic</td>
<td>Ovate-oblong</td>
<td>ovate</td>
<td>Oblong-elliptic</td>
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<tr>
<td>Lamina apex</td>
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<td>rounded</td>
<td>acute</td>
<td>acute</td>
<td>acute</td>
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<tr>
<td>Lamina base</td>
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<td>Pairs of leaflets</td>
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<td>4-6</td>
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<tr>
<td>Leaf length in cm</td>
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<td>ovate</td>
<td>subulate</td>
<td>lunate</td>
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<td>Inflorescence type</td>
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<td>Racemose corymb</td>
<td>Terminal raceme</td>
<td>Lateral raceme</td>
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<td>Velvety pubescent</td>
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<td>obovate</td>
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<td>S-shaped filament</td>
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<td>Nodulated filament</td>
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Cytological review work on the genus *Cassia*.

- Chromosome number and morphological characters of ten species of genus *Cassia* belonging to two subgenera; *Fistula* and *Senna*, are discussed by Ahmed Ghareebi, Sayd F. Khalifa 2 and Nael Fawzi 3 (1999). The phylogenetic relationship between the species are also evaluated based on numerical analysis criterion. According to numerical cluster analysis method the studied taxa are splitting into two groups; Group 1 (belonging to subgenus fistula) includes 2 species *C.fistula* and *C.renigera* while *C.occidentalis*, *C.siamea*, *C.sophera* are representing Group 2 (belonging to subgenus *Senna*).

  - Darlington and Wylie (1956) listed, in their Chromosome Atlas, three basic numbers of x=6, 7 and 8 and parenthetically, a secondary basic number of x=13. Irwin and Turner (1960) suggested that the basic number for the genus *Cassia* is x=7 which confined to Subsection Xerocalyx, Section Chamaecrista and Subgenus Lasiorhegma. They added that the other basic numbers (x = 6, x=8) have been derived by aneuploid either loss or gain of one chromosome.

  - Karyotypes of 17 taxa of *Cassia* from North Indian plains and Central Indian Hills have been worked out by S S Bir and Santosh Kumari (1982). The chromosomes are small-sized but reflect great differences in size within the related species. There is no correlation between habit and karyotype symmetry of various species. However, the ploidy level and the total haploid chromatin length show some relationship. As compared to trees, the shrubby species seemed to have more evolved karyotype. All the investigated *Cassia* species were found to have same chromosome number (i.e;2n=28), but the chromosome sizes differed (*Cassia fistula* (1.01-2.22); *Cassia sophera* (0.92-2.31); *Cassia siamea* (0.80-1.48); *Cassia occidentalis* (0.74-1.48); *Cassia javanica* (1.01-1.75)).

  - Somatic chromosome number studied by Mohanty and Das (2006). Root tip meristematic cells were pretreated in aqueous solution of p-dichlorobenzene and
aesculine followed by the fixation in carnoy's solution for chromosome analysis and the method of cytophotometry was followed for the estimation of nuclear DNA content. Somatic chromosome number $2n=28$ was observed in all the species of Cassia we are dealing with. In addition, aneuploid/polyploid chromosome number plates were observed in *C.siamea* i.e, $(2n=14,28,35)$; *C.fistula* i.e, $(2n=24,28)$. While studying the chromosome characteristics it was found that *Cassia* in general is characterized by small size chromosomes. Though most of the species have same number of diploid chromosomes, they differ in their minute details of the karyotype. The different species could be distinguished from one another on the basis of their variation in karyotype and total chromosome length (TCL). The chromosomes are mostly median to submedian constricted. On the basis of the size of the chromosome and the position of the primary and secondary constrictions, a number of chromosome types were found to be common among the studied species that showed differences in number in each species. A general description of the representative types of chromosomes is given in Table 2.

**Fig. 1: Standard chromosome types found in Cassia**

**TYPE A:** Medium sized chromosomes with two constrictions in nearly median and nearly sub-terminal positions.

**TYPE B:** Medium sized chromosomes with two constrictions one on median to nearly median and the other a satellite body on the long arm.

**TYPE C:** Medium sized chromosomes with median to nearly median primary constriction.

**TYPE D:** Medium sized chromosomes with sub-median to nearly sub-median primary constriction.

- Type A, B, C and D are present in *C.javanica* and *C.siamea*. Though median and sub-median constricted Type C and D chromosomes were found in all the species, their dose differences were the most striking features. The tree species *C.fistula* has highest number (24) of Type C chromosomes. Secondary constricted Type A chromosomes absent in *C.fistula*. Secondary constricted Type B chromosomes absent in *C.occidentalis* and *C.glauca*. Highest number of Type B chromosomes found in *C.siamea* in which aneuploid number $2n=14$ and $2n=35$ number of chromosomes were also found in their somatic cells in addition to the normal $2n=28$ chromosomes.
• Meiotic behavior, pollen morphology, interphasic nucleus pattern and karyotype description for *Senna occidentalis* (Caesalpinioideae — Fabaceae) were presented by Ferreira et al. (2010). The species had non-reticulate interphasic nucleus and homogeneous chromosome two chromosome pairs bearing Nucleolar Organizer Region (NOR). Meiotic behavior was regular, condensing with minute distal late-condensing portions in prometaphase. In mitotic metaphase, chromosome number was $2n = 28$ (9 m + 5 m), with secondary constriction in one chromosome pair. Detection of four nucleoli indicated existence of with high meiotic index (95%). Pollen grains, classified as polar/spheroidal, presented 90% viability.

• Karyotypic studies in *Cassia* Linn. From India by S S Bir and Santosh Kumari showed that the chromosomes are small sized but reflect great differences in size within related species. There is no correlation between habit and karyotype symmetry of various species. However the ploidy level and the total haploid chromatin length show some relationship. A detailed karyotype analysis of different species reveals wide differences between their complements. Further, the identity of various species is recognized by minute differences in the finer details such as chromosome size, position of primary constrictions and the presence or absence of secondary constriction or satellites. It was observed secondary constriction most common on the chromosomes of shrubs i.e; *C.sophera, C.occidentalis*. Sat pairs not observed in *C.sophera*, although earlier Datta and Datta had reported their presence. For *C.siamea*, there is some differences in meta- and sub-metacentric chromosomes ratio, which bring to light the fact that karyotypic variations exist in various populations of the same species and this emphasises the fact that microevolution is taking place presently. The mechanisms involved are structural changes and gene mutations. Analysis of karyotypes according to Stebbins(1958) indicates *Cassia* species have moderately to highly symmetrical karyotypes. Habit of various members does not have any correlation with the karyotype symmetry.

**Table 2: Chromosome numbers of different species of Cassia as worked out by different authors**

<table>
<thead>
<tr>
<th>species of <em>Cassia</em></th>
<th>Chromosome numbers</th>
<th>Authors with the date of publication</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cassia fistula</em> Linn.</td>
<td>24</td>
<td>Tischler, G.1921-1922; Nanda, p.c.1962; Datta, F.M and Jena, P.K.1974</td>
</tr>
<tr>
<td></td>
<td>24,28</td>
<td>Irwin, H.S. and Turner, B.L.1960; Mehra, P.N.1962</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>Bir, S.S and Sidhu, S.1966</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Pantulu, J.V,1942,1947; Sampath, S. And Ramanathan, K.1949; Atchison, E.1951</td>
</tr>
<tr>
<td>28,56</td>
<td>Irwin, H.S. and Turner, B.L.1960; Pantulu, J.V.1960a</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>Chatterjee, P.1969</td>
<td></td>
</tr>
<tr>
<td>26,28</td>
<td>Irwin, H.S. and Turner, B.L.1960; Miege, J.1962; Mehra, P.N.1972</td>
<td></td>
</tr>
<tr>
<td><strong>Cassia siamea</strong> Lam.</td>
<td>26,28</td>
<td>Tandon, S.L. and Bhat, R.N.1971</td>
</tr>
<tr>
<td><strong>Cassia sophera</strong> Linn.</td>
<td>24</td>
<td>Kawakami, I 1930; Ramanathan, K.1955b</td>
</tr>
</tbody>
</table>

**Morphometric analysis:** The diagnostic morphological characters of plants were examined for assessing the degree of overall phonetic similarity between the investigated species. In the morphometric (multivariate) analysis, each species is being considered here as an Operational Taxonomic Unit (OTU). Since the problem of character weighing is still a controversial subject, no differential weighing of characters was attempted. The character states were coded as binary alternatives, ‘1’ for the presence and ‘0’ for the absence. A matrix of similarity coefficients was prepared using “Pearson correlation “ coefficient value as a measure of similarity between each OTU pairs. With the help of this correlation coefficient matrix, cluster analysis was performed to draw phenogram among OTUs using UPGMA (Unweighted pair-group with arithmetic average). These morphometric analyses were carried
Twenty-two morphological characters were selected for investigation (Table 3). Cluster analysis based on UPGMA method revealed the presence of distinct clusters among the investigated taxa as indicated in phenogram (Fig. 2). The results exhibited through this phenogram have been interpreted with morphological characters and compared with evidences and support from other fields wherever applicable.

Table 3: Characters used in Morphometric analysis

<table>
<thead>
<tr>
<th>Sl no</th>
<th>characters</th>
<th>Sl no</th>
<th>characters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Habit</td>
<td>12</td>
<td>S-shaped filament</td>
</tr>
<tr>
<td>2</td>
<td>Phyllotaxy</td>
<td>13</td>
<td>Nodulated filament</td>
</tr>
<tr>
<td>3</td>
<td>Lamina shape</td>
<td>14</td>
<td>Anther size</td>
</tr>
<tr>
<td>4</td>
<td>Lamina apex</td>
<td>15</td>
<td>Anther attachment</td>
</tr>
<tr>
<td>5</td>
<td>Lamina base</td>
<td>16</td>
<td>Anther dehiscence</td>
</tr>
<tr>
<td>6</td>
<td>Pairs of leaflets</td>
<td>17</td>
<td>Fruit valves</td>
</tr>
<tr>
<td>7</td>
<td>Leaf length in cm</td>
<td>18</td>
<td>Fruit shape</td>
</tr>
<tr>
<td>8</td>
<td>Stipule shape</td>
<td>19</td>
<td>Inner part of fruit</td>
</tr>
<tr>
<td>9</td>
<td>Inflorescence type</td>
<td>20</td>
<td>Seed shape</td>
</tr>
<tr>
<td>10</td>
<td>Sepal vestiture</td>
<td>21</td>
<td>Seed areolae</td>
</tr>
<tr>
<td>11</td>
<td>Petal vestiture</td>
<td>22</td>
<td>Seeds individually enveloped in corky discs</td>
</tr>
</tbody>
</table>
The ultimate outcome of the 6 taxa through phenogram reveals the presence of two clusters among the investigated taxa, cluster I comprising of 2 taxa and cluster II of 4 taxa. These two major clusters are mainly separated from each other on the basis of the type of dehiscence of pod and its shape. Pod of all taxa in cluster I are indehiscent, woody and terete whereas cluster II is characterized by dehiscent pod which is compressed, rarely turgid and sub-terete.

Cluster I

Cluster I is comprising of 2 species of the genus Cassia namely Cassia fistula L. and Cassia javanica L. Cluster I consists of 2 taxa of which 1 taxa is characterized by 4-8 pairs of leaflets, pendulous inflorescence, bright-yellow flowers in long raceme corymb, minute and deciduous bracts and the other taxa is characterized by 8-20 pairs of leaflets, erect inflorescence, pink flowers in paired lateral racemes, large and persistent bracts. The closer relationship observed between C. javanica and C.fistula is in conformity with cytological studies where both of these taxa have identical chromosome size. (Bir and Kumari, 1982)

Cluster II

Cluster II is divided into two sub clusters which differs from each other on the basis of presence of foliar glands, shape of bracts and seeds. Cluster II is segregated into one small cluster IIA comprising of one taxa (i.e; Cassia siamea), and 3 other taxa in another cluster IIB (i.e; Cassia occidentalis Linn., Cassia sophera, Cassia glauca) which differ from the former taxa in presence of foliar glands.

In Cassia siamea (cluster IIA), foliar glands absent, bracts obovate and seeds bean-shaped whereas in the other 3 taxa foliar gland is present, bracts ovate, seeds ovoid, compressed or oblong-elliptic. Cluster IIB is further segregated into IIB (i) and IIB (ii) on the basis of position of glands. IIB(i) comprising of 2 species (i.e; Cassia occidentalis and Cassia sophera). In IIB (i) gland is present near the base of petiole. Cassia occidentalis is characterized by ovoid gland and ovate to oblong leaflets. Cassia sophera is characterized by sub-acute gland and oblong to lanceolate leaflets. IIB (ii) comprising of only one species(i.e; Cassia glauca). Here lowermost gland is present between lowest pair of leaflets.

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Plate 1: (a) *C. fistula* L.; (b) *C. glauca* Lam.; (c) *C. javanica* L.; (d) *C. occidentalis* Lam. (e) *C. siamea* L. (f) *C. sophora* L.