



# COMPARATIVE STUDIES OF TWO ECOLOGICALLY IMPORTANT SPECIES OF GENUS *CLEOME*

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## ABSTRACT

A comparative study was conducted between two ecologically important species of genus *Cleome*. Selection of genus *Cleome* is because this genus has both  $C_3$  and  $C_4$  species and study of this genus can show the transition from  $C_3$  to  $C_4$  photosynthesis. Morphological studies show that *Cleome gynandra* contains white flowers with gynandrophore, while *Cleome viscosa* contains yellow flowers without gynandrophore. Leaves of both *Cleome gynandra* and *Cleome viscosa* are pentafoliate palmately compound but differing only in tip structure as *Cleome gynandra* leaflet contains acute tip while *Cleome viscosa* leaflet have obtuse tip. These are some visually distinguishing features of both the plants. Transverse section of *Cleome gynandra* shows the presence of prominent bundle sheath cells which supports the fact that this is a  $C_4$  plant where as no differentiation was found between the bundle sheath cells and mesophyll cells in the transverse section of leaf of *Cleome viscosa*. Stomata distribution in both the species is almost similar. Venation pattern of both the species shows *Cleome gynandra* have denser veins than *Cleome viscosa*.

## KEY WORDS

*Cleome gynandra*, *Cleome viscosa*,  $C_3$  plants,  $C_4$  plants, Vein clearing

## 1. Introduction

Plant species with adaptations to grow well even at elevated levels of  $CO_2$  are going to be important in the era of climate change and global warming. Which type of plant will be more susceptible to the climate change and the higher levels of  $CO_2$ ? Will it be  $C_3$  or  $C_4$  plants? Plant species with  $C_4$  photosynthesis have genetic, biochemical, physiological and ecological traits that make them suitable for biomass production [1, 2]. The selected genus *Cleome* have both  $C_3$  and  $C_4$  plants species. *Cleome* is the largest genus from family Cleomaceae comprising 180 to 200 species of herbaceous annual or perennial plants and shrubs widely distributed in tropical and subtropical regions [3]. Many of the workers previously treated this genus in family Capparaceae, until DNA studies (APG II system) found that the major Cleomaceae members are closer to Brassicaceae than Capparaceae [4]. Economically the genus *Cleome* is not much admired. The genus *Cleome* is under constant evolution, many species show a developmental progression from  $C_3$  photosynthesis to  $C_4$  photosynthesis and this evolutionary progression is identical to Brassicaceae members like *Arabidopsis thaliana*. There is very scanty and scattered work in the genus *Cleome* [5, 6]. Particularly, the anatomical and biochemical studies in the species are rare.



Therefore the present work represents the comparative studies of two important ( $C_3$  and  $C_4$ ) species of genus *Cleome* including *C. gynandra* ( $C_4$  plant) and *C. viscosa* ( $C_3$  plant).

## 2. Materials and methods

### 2.1. Morphological studies

For morphological studies the external morphology was compared including flowers, leaves etc and the differences were recorded.

### 2.2. Anatomical studies

Transverse section of leaves from both the plants i.e. *C. viscosa* and *C. gynandra* were cut, observed under the microscope and differences were recorded. To observe the changes in structure and function of developing stomata, epidermal peel was separated manually from leaves. We also studied the development of veins (vein density and pattern of venation) in leaves by vein clearing experiment. Whole leaves (at least 3 - 5 from each stage of plantlets) were fixed and cleared in 70% ethanol (v/v) until chlorophyll was removed, bleached with 5% (w/v) NaOH, and rinsed three times in water. The leaves were then stained with 1% safranin (Loba chemie, India) and mounted in water and examined under microscope (Leica DM 3000). Images for all these experiments were captured and analysed by the software Leica application suite V 3 1.0.

## 3. Results

### 3.1. Morphological studies

Morphological studies show that *C. gynandra* contains white flowers with gynandrophore (Fig.1a) while *C. viscosa* contains yellow flowers without gynandrophore (Fig.1b). Leaves of both *C. gynandra* and *C. viscosa* are pentafoliate palmately compound (Fig. 1c & 1d) but differing differing only in tip structure as *C. gynandra* leaflet contains acute tip (Fig. 1e) while *C. viscosa* leaflet have obtuse tip (Fig. 1f).

### 3.2. Anatomical studies

3.2.1. Transverse section of leaf of *C. gynandra* shows the presence of prominent bundle sheath cells (Fig. 2a) which supports the fact that this is a  $C_4$  plant where as there was not any differentiation was found between the bundle sheath cells and mesophyll cells (Fig. 2b) in the transverse section of *C. viscosa* leaves.

3.2.2. Stomata of leaves of both *C. gynandra* and *C. viscosa* are almost similar (Fig. 2c & 2d).

3.2.3. Venation studies showed that the leaves of both *C. gynandra* have denser veins (Fig. 2e) then *C. viscosa* (Fig. 2f).

## 4. Discussions

The genus *Cleome*, the largest genus of family Cleomaceae is phylogenetic near relative of genus *Arabidopsis*, contains both  $C_3$  and  $C_4$  species [7]. However, *C. gynandra* is a  $C_4$  plant due to presence of Kranz anatomy and low  $CO_2$  compensation point and *C. viscosa* is a  $C_3$  plant due to lack of Kranz anatomy and high  $CO_2$  compensation point [8]. A comparative study was conducted between these two important species of genus



*Cleome* found in Thar Desert. Morphological studies show that *C. gynandra* contains white flowers with gynandrophore, while *C. viscosa* contains yellow flowers without gynandrophore. These are some visually distinguishing features of both the plants. Transverse section of leaf of *C. gynandra* shows the presence of prominent bundle sheath cells which supports the fact that this is a C<sub>4</sub> plant where as no differentiation was found between the bundle sheath cells and mesophyll cells in the transverse section of leaf of *C. viscosa*. Earlier, several workers also reported the venation patterns and compared C<sub>4</sub> and C<sub>3</sub> species of genus *Cleome*, C<sub>4</sub> plants have dense veins as compared to C<sub>3</sub> plants [9]. The genus *Cleome* is under the prime focus due to similarities with genus *Arabidopsis*. Previously there are few reports on tissue culture work of genus *Cleome* [10, 11]. There are also reports on molecular marker analysis of genus *Cleome* [12].

## 5. Conclusion

A comparative study was conducted between these two important species of genus *Cleome*. Morphological studies show that *C. gynandra* contains white flowers with gynandrophore, while *C. viscosa* contains yellow flowers without gynandrophore. Leaves of both *C. gynandra* and *C. viscosa* are pentafoliate palmately compound but differing only in tip structure as *C. gynandra* leaflet contains acute tip while *C. viscosa* leaflet have obtuse tip. These are some visually distinguishing features of both the plants. Transverse section of *C. gynandra* shows the presence of prominent bundle sheath cells which supports the fact that this is a C<sub>4</sub> plant where as no differentiation was found between the bundle sheath cells and mesophyll cells in the transverse section of leaf of *C. viscosa*. Stomata distribution in both the species is similar but vein density is higher in *C. gynandra* than *C. viscosa*.

## 6. Acknowledgements

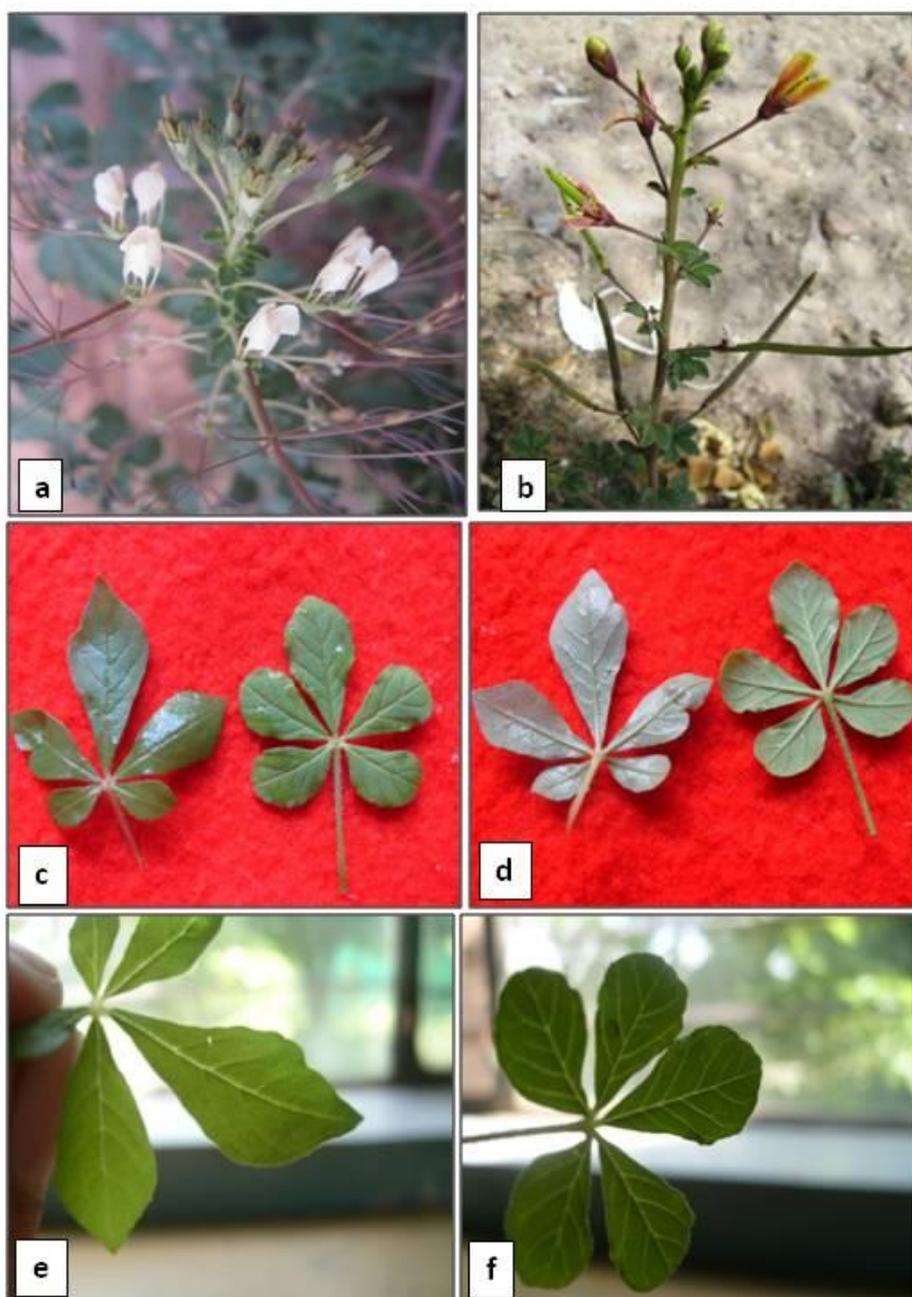
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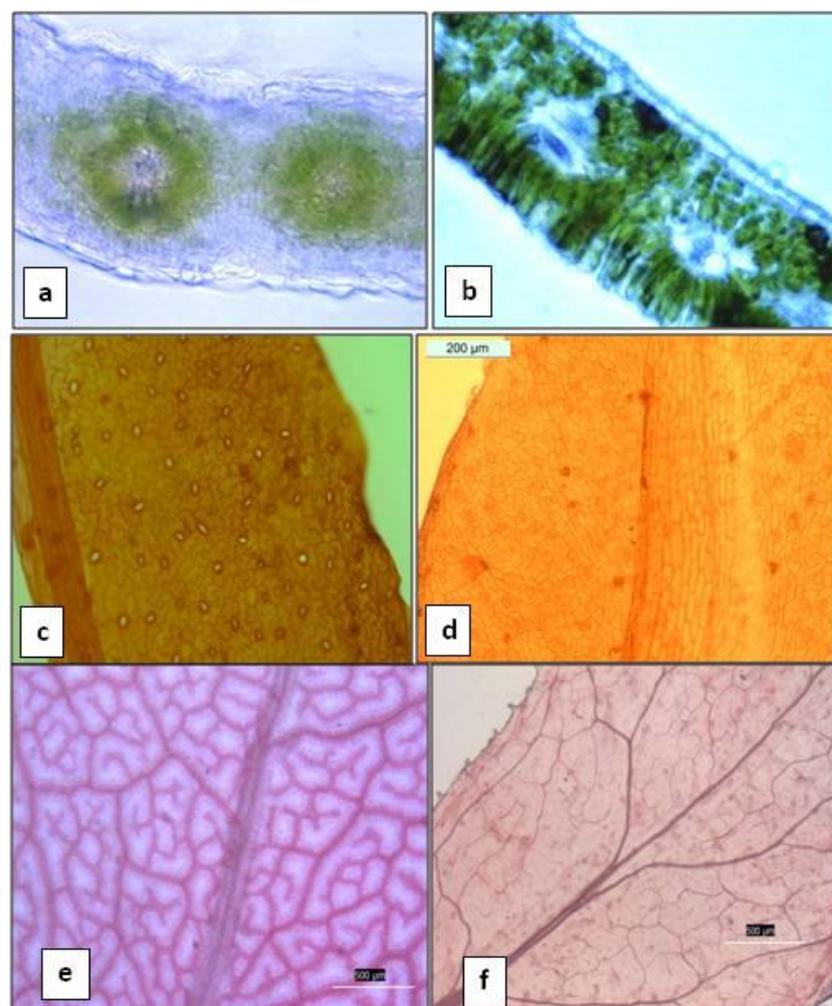
**Fig. 1: Morphological comparison of *C. gynandra* and *C. viscosa***

(a) & (b) Inflorescence axis of *C. gynandra* and *C. viscosa* respectively

(c) Dorsal view of leaves of *C. gynandra* and *C. viscosa* respectively

(d) Ventral view of leaves of *C. gynandra* and *C. viscosa* respectively

(e) & (f) Leaves of *C. gynandra* and *C. viscosa* showing acute and obtuse tip respectively



**Fig. 2: Anatomical comparisons of *C. gynandra* and *C. viscosa***

- (a) & (b) V. T. S. of leaf of *C. gynandra* and *C. viscosa* respectively
- (c) & (d) Stomata in leaf of *C. gynandra* and *C. viscosa* respectively under *in vitro* condition
- (e) & (f) Venation pattern in leaves of *C. gynandra* and *C. viscosa* respectively