Chapter 5

Observation
5.1 General descriptions of the presently studied species of *Carex* L.

The present study of the genus *Carex* L. is done for 23 species (24 taxa) collected from North-eastern India especially from the Sikkim Himalaya and from the Darjeeling district of West Bengal. The field studies of the specimens, observation of the population, finally descriptions of both morphological and anatomical features including scanning electron microscopic study of utricles and nuts have provided the following general account of the characteristic features of studied species of *Carex* L.

It is observed that mycorrhizal association of some species of *Carex* L. is the important finding and that has been provided as a separate account under observation.

It is worthy to mention here again that both field characters and the floral biology including the anatomical features all are the important characters for the study of the genus *Carex* L. All these characters are used to place the genus *Carex* L. in Cyperaceae under a separate subfamily *Cyperoideae* or under a separate tribe *Cariceae* including some other genera. Moreover, these characters are useful for the classification of the genus *Carex* L. into the infrageneric rank to subgenera and sections as well. Furthermore, the evolutionary aspects and the phylogeny of this genus *Carex* L. and its subgenera as well as sections can be of better understanding.

These general accounts of the characteristic features of the studied species of *Carex* L. with examples are provided below:

The plants are either stoloniferous or rhizomatous and most of the studied species are rhizomatous (Fig. 20). Plants may be phyllopodic with leafy nature or aphyllopodic with bladeless sheathing leaves (Fig. 20). The presence of the number of modules in a tuft in a plant is also an important feature as *C. burttii* has 50-70 modules, *C. inanis* and *C. breviculmis* have upto 100 as maximum count while least number is present in *C. baccans, C. alopecurooides* as 2-5.

The roots are always fibrous, of different colouration, grow as profuse aggregation.
The leaves in the rhizomatous plant or in stems of ground level and above ground level may be of bladeless with sheathing bases or with leaf blades. The leaf-sheaths bear some important features including the ligular nature and the existence of different fibrous natures of the remnants of older leaves. The lamina or leaf blades, however, provide more important features in folding nature and too much in the anatomical structures.

The culms have the inflorescence, leafy bracts, flowering peduncles, spikes and the arrangements of different sexes in a spike and all these features are forming a unique nature of synflorescence in Carex L. (Fig. 21). The details of each feature for each species was thoroughly described. Basically spikelet is inflorescence of Carex L. as like other genera of Cyperaceae. However, as a general account it can be summarized that the pseudoflorescence is the basic unit of synflorescence in Carex L. (Fig. 21). Further details are also found as simple truncated-pseudoflorescence in C. nubigena, spikoloidium-pseudoflorescence in C. rochebrunii, antheloidium-pseudoflorescence in C. teres, fasciculoidium-pseudoflorescence in C. insignis and paniculoidium-pseudoflorescence in C. stramentitia (Fig. 21). The number of flowering nodes per module and the number of peduncle and spike per node are also the important account for the identity of the species. The arrangements of male, female as well as sterile flowers in a spike are the important criteria of identity of species or a group of species under a section. Thus the study of the pistillate portion, staminate portion and the position of sterile flowers are too much important for the identity of species which is quite different as well as characteristic for species (Fig. 22). The synflorescence and the distribution of sexes were thoroughly studied and here represented for studied species (Figs. 22-28). The simplest form is noted in case of C. baccans (Fig. 22) and gradually complex nature is observed in C. teres (Fig. 27) and also in C. rochebrunii (Fig. 28). The arrangements of sexes are mostly androgynous in many of the studied species. However, some species are gynaeandrous as in C. rochebrunii. So also C. teres shows variations as gynaeandrous and mesogynous.

The nature of bract, leafy in nature, prophyll, etc. are also important features which provide some characters for grouping of species as these are shorter than the inflorescence structure, or equal to the inflorescence, or exceeding the top of inflorescence structure.
The count of the flowering glumes provides some important information for the identity of species specially whenever there are the presence of sterile glumes and their position of arrangement. *C. insignis*, thus can be identified by the presence of more number of sterile glumes and their arrangements as basal, middle as well as upper position. In *C. cruciata* var. *nagporensis* although their position is basal but variable in count which can be of useful study to separate *C. cruciata* var. *argocarpous* where there are 1-2 basal sterile glumes. Of course, many of the studied species do not have sterile glumes.

Morphological characters of glumes as shape, size, apex, vein, colour, etc. provide most important features for the study of individual species of *Carex* L. The apices of glumes as cuspidate, awned and their surface features as muricate, mucronate, scabrid, hispid etc. provide many important information (Figs. 29-31).

In the male flower the stamens are mostly 3 in number. Stamens are mostly isomorphic (Fig. 32). However, the length of filaments may be very shorter in some species or may be equal in size. In *C. composita* and *C. daltonii* the length of filaments is very short. The equal size of filament with that of the anther length is found in *C. setigera*. The anthers have mostly apiculate appendage above and that appendage structure is different in many species. Moreover, the surface of appendages is often having unique feature as hispid, hispidulous, or often spinous nature. The hispidulous nature is found in *C. composita, C. daltonii* and *C. rochebruni*, *C. stramentitia*, etc. (Fig. 32).

The gynoecium or pistil of *Carex* L. is although not unique for the identity but may often provided the features of ovary and stigma as unique for identity. The stigmatic surface is also different in few cases.

The utricles or perigynia are the important structural features and that are mostly used for identification. The shape, size, surface, veins and beak of utricle of *Carex* L. should be studied in details for the identity (Fig. 33, 34) of species. The cellular compositions of the costal and intercostal areas, surface ornamentations as hispid, scabrid nature are the most important morphological features of many species of *Carex* L. Under SEM the cellular details can be used for identity of species (Pl. V).
Nuts of *Carex* L. provide more information of shape, size, and surfaces as well as many additional taxonomic characters. Besides shape and size, basal carpopodium structure and even the apex of nut are different in different species (Fig. 35). The stipitate nuts of *C. teres*, *C. polycephala*, *C. nubigena* and *C. setigera* are nodoubt different from other species of *Carex* L. The scanning electron microscopic (SEM) study of the surfaces of nuts provide more information of the cellular nature, presence or absence of silica bodies, etc. (Pl. VI). Furthermore, the associated features of silica bodies, nature of silica bodies, etc. are the important features whenever observed under scanning electron microscopical study (Pl. VII).

The culm structures under transverse section, in regards to the shape, are different in nature. The triangular nature is more common as in *C. cruciata*, *C. alopecuroides*, *C. teres* etc. The circular outline of culm is also found in *C. nubigena* and *C. rochebrunii*. The outer surface may be of different nature as truncate, or ridged and furrowed or even wavy under transverse section. The number of vascular bundles, their corresponding arrangement, association of air cavities, assimilatory tissue and the ground tissue as a whole are the bearing of many anatomical information that all are of taxonomic value (Fig. 36; Pl. VIII). The distribution of sclerenchymatous tissue and the arrangement with vascular bundles, nature of occurrence within the other tissue system, etc. are the important anatomical features of interest. The midrib, keel region, lateral part of lamina and the margins provide many more information to recognize the anatomical features of interest (Pl. IX). Any outgrowth from the epidermis at adaxial surface; presence of bulliform cells, etc. are the important features of taxonomic value (Pls. IX, X and XI). The number, shape and size of the bulliform cells in the lamina can also be the useful feature of species identity.

Based on the 23 studied species of *Carex* L. it is confirmed that both morphological and anatomical characters are always required for the study of *Carex* L. *Carex* L. has a good number of species and thus also provides a good number of characters, diversity of characters, distribution of characters, etc. All the characters must be emphasized for proper identity of species of *Carex* L.
Table 6 Description of characters for all variables as leaf, culm and microcharacters of nut scored in next table 7 (After Starr and Ford, 2001)

<table>
<thead>
<tr>
<th>Characters</th>
<th>Description of character states/variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anatomy of leaf blade</strong></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Leaves lightly W-shaped or curved (C) vs. flat or V-shaped (V)</td>
</tr>
<tr>
<td>2.</td>
<td>Thickest point of lamina the thickness of the keel (E) vs. &gt;keel (T)</td>
</tr>
<tr>
<td>3.</td>
<td>Keel, shape acute (A) vs. rounded or flat (R)</td>
</tr>
<tr>
<td>4.</td>
<td>Bulliform cells = The largest epidermal cells (E) vs. &gt; the largest epidermal cells (L)</td>
</tr>
<tr>
<td>5.</td>
<td>Leaf margins sclerified completely (C) vs. sclerified incompletely (I) vs. both states equally probable (E)</td>
</tr>
<tr>
<td>6.</td>
<td>Minor vascular bundles, often overlaping air cavities (O) vs. between the air cavities (B)</td>
</tr>
<tr>
<td>7.</td>
<td>Adaxial girders often interrupted by parenchymatous cells (I) vs. completely sclerified (S)</td>
</tr>
<tr>
<td>8.</td>
<td>Minor vascular bundles sclerified on both sides (S) vs. non sclerified (N)</td>
</tr>
<tr>
<td>9.</td>
<td>Leaf epidermal surfaces with the presence of marginal papillae (P) vs. absence of epidermal papillae (A)</td>
</tr>
<tr>
<td>10.</td>
<td>Adaxial surface of leaf with the presence of papillae (P) vs. adaxial surface of leaf with the absence of papillae (A)</td>
</tr>
<tr>
<td>11.</td>
<td>Bulliform cells inflated (I) vs. well developed elongation (T)</td>
</tr>
<tr>
<td>12.</td>
<td>Number of vascular bundles more than ten pairs (T) vs. less than ten pairs (L)</td>
</tr>
<tr>
<td><strong>Anatomy of culm</strong></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Minor vascular bundles completely embedded within chlorenchyma (C) vs. resting within central ground tissue (R)</td>
</tr>
<tr>
<td>14.</td>
<td>Culm highly sclerified (H) vs. typical (T)</td>
</tr>
<tr>
<td>15.</td>
<td>Number of angles or wings three (T) vs. three to five (F)</td>
</tr>
<tr>
<td>16.</td>
<td>Angles of wing strongly sclerified (S) vs. weakly sclerified (W)</td>
</tr>
<tr>
<td>17.</td>
<td>Presence of epidermal papillae (P) vs. absence of papillae (A)</td>
</tr>
<tr>
<td><strong>Micro morphology of nuts</strong></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Silica platform concave (C) vs. silica platform convex (V)</td>
</tr>
<tr>
<td>19.</td>
<td>Margins of silica platform thickened forming tough (T) vs. margins not thickened (N)</td>
</tr>
<tr>
<td>20.</td>
<td>Silica platform distinctly raised (D) vs. not raised (R) (-) not applicable/comparable</td>
</tr>
<tr>
<td>21.</td>
<td>Silica platform, ornamented (O) vs. not ornamented (N)</td>
</tr>
<tr>
<td>22.</td>
<td>Presence of satellite bodies (P) vs. absence of satellite bodies (A)</td>
</tr>
</tbody>
</table>

Notes: Characters are those most commonly observed for each species; full range variations of characters described thoroughly in the descriptions of the text.
Table 7 Character states matrix for all variables as leaf, culm and epidermal silica body characters of nuts observed in the present study of 23 species (24 taxa) of *Carex*.

<table>
<thead>
<tr>
<th>Names of the studied taxa</th>
<th>Anatomy of leaf-blade</th>
<th>Anatomy of culm</th>
<th>Micromorphology of nuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Carex baccans</em></td>
<td>V T A L I B S I</td>
<td>N A A T T R</td>
<td>H T S W T W T W T W T A</td>
</tr>
<tr>
<td>3. <em>Carex spiculata</em></td>
<td>C E A L I B S I</td>
<td>N P P I T C</td>
<td>H T S W T W T W T W T A</td>
</tr>
<tr>
<td>4. <em>C. composita</em></td>
<td>C T R E I B L S</td>
<td>S A A T L R</td>
<td>T T W A C N D N N</td>
</tr>
<tr>
<td>5a. <em>C. cruciata</em></td>
<td>V T A L I</td>
<td>B I N A A T T R</td>
<td>H T S A - - - - - - - -</td>
</tr>
<tr>
<td>5b. <em>C. cruciata</em> var. <em>argocarctica</em></td>
<td>V T A L I</td>
<td>B I N A A T T R</td>
<td>H T S A - - - - - - - -</td>
</tr>
<tr>
<td>7. <em>C. strangulata</em></td>
<td>C T A L I B S I</td>
<td>N A A P P T T T</td>
<td>H T S W T W T W T W T A</td>
</tr>
<tr>
<td>8. <em>C. filicina</em></td>
<td>C E R E I B S I</td>
<td>N A A P P T T T</td>
<td>H T S W T W T W T W T A</td>
</tr>
<tr>
<td>9. <em>C. continua</em></td>
<td>C T A L I B S I</td>
<td>N A A P P T T T</td>
<td>H T S W T W T W T W T A</td>
</tr>
<tr>
<td>11. <em>C. inanis</em></td>
<td>V T R L I O S</td>
<td>S P P I L C</td>
<td>H T W A S A C T D O A</td>
</tr>
<tr>
<td>12. <em>C. setigera</em></td>
<td>V T R L I O S</td>
<td>S P P I L C</td>
<td>H T W A S A C T D O A</td>
</tr>
<tr>
<td>Name of the studied taxa</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>------------------------------------------</td>
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</tr>
<tr>
<td>15. <em>C. daltonii</em></td>
<td>V</td>
<td>T</td>
<td>R</td>
</tr>
<tr>
<td>18. <em>C. finitima</em></td>
<td>V</td>
<td>E</td>
<td>R</td>
</tr>
<tr>
<td>19. <em>C. alopecuroides</em></td>
<td>V</td>
<td>E</td>
<td>A</td>
</tr>
<tr>
<td>20. <em>C. teres</em></td>
<td>C</td>
<td>E</td>
<td>R</td>
</tr>
<tr>
<td>22. <em>C. nubigena</em></td>
<td>V</td>
<td>T/E</td>
<td>R</td>
</tr>
</tbody>
</table>
Fig. 20. Stem morphology of *Carex* spp.

A. Stoloniferous; B. Rhizomatous; C. Phyllopodic; D. Aphyllopodic. (All diagrammatic - not after scale)
Fig. 21. Synflorescence types in Carex L.

A. Pseudoflorescence—the basic unit of synflorescence of Carex L.; B. Simple truncated pseudoflorescence of C. nubigena; C. Spikolidium-pseudoflorescence of C. rochebrunii; D. Arrangement of flowers of different sexes on single spike of C. rochebrunii; E. Antheloidium-pseudoflorescence of C. teres; F. Fasciculoidium—pseudoflorescence of C. insignis; G. Arrangement of flowers of different sexes on single spike of C. insignis; H. Paniculoidium-pseudoflorescence of C. stramentitia. (All diagrammatic—not after scale)

--- Male flower, 🌿 Female flower, 🌸 Sterile flower
Fig. 22. Synflorescence in different species of Carex L. (showing distribution of sexes): 
A. and B. C. baccans; C. and D. C. myosurus; E. and F. C. spiculata.
(All diagrammatic- not after scale)

– Male flower, — Female flower, - Sterile flower
Fig. 23. Synflorescence in different species of Carex L. (showing distribution of sexes)

A. C. compositor; B. and C. C. cruciata var. argocarpus; D. C. cruciata var. nagporensis; E. and F. C. burttii (All diagrammatic- not in scale)

[Diagram with labels: Male flower, Female flower, Sterile flower]
Fig. 24. Synflorescence in different species of Carex L. (showing distribution of sexes):
A. and B. C. stramentitia; C. C. filicina; D. and E. C. continua; F. C. condensata

(All diagrammatic - not in scale)

♂ Male flower, ♀ Female flower, ♀ Sterile flower
Fig. 25. Synflorescence in different species of Carex-L. (showing distribution of sexes)
A. C. inanis; B. C. setigera; C. C. breviculmis.

(All diagrammatic - not in scale)

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Male flower, Female flower, Sterile flower
Fig. 26. Synflorescence in different species of *Carex* L. (showing distribution of sexes)

A. *C. speciosa*; B. and C. *C. daltonii*; D. *C. insignis*; E. *C. polycephala*. F. *C. finitima*.

(All diagrammatic- not in scale)

- **Male flower**
- **Female flower**
- **Sterile flower**
Fig. 27. Synflorescence in different species of Carex L. (showing distribution of sexes)

A. and B. C. alopecuroides; C. C. longipes; D and E. C. teres

(All diagrammatic - not in scale)

- Male flower
- Female flower
- Sterile flower
Fig. 28. Synflorescence in different species of Carex L. (showing distribution of sexes)
A. C. nubigena; B. and C. C. rochebrunii.

(All diagrammatic - not in scale)

- Male flower,  - Female flower,  - Sterile flower
Fig. 29. Morphology of glumes of female flowers of Carex L.
A. C. baccans; B. C. myosurus; C. C. spiculata; D. C. composita; E. C. cruciata var. argocarpus:
F. C. cruciata var. nagporensis; G. C. burtii; H. C. stramentitia
(All diagrammatic- not in scale)
Fig. 30. Morphology of the glumes of female flowers of *Carex* L.

A. *C. filicina*; B. *C. continua*; C. *C. condensata*; D. *C. inanis*; E. *C. setigera*; F. *C. breviculmis*; G. *C. speciosa*; H. *C. daltonii*; I. *C. insignis*

(All diagrammatic— not in scale)
Fig. 31. Morphology of the glumes of female flowers of *Carex* L.

A. *C. polycephala*;
B. *C. finitima*;
C. *C. longipes*;
D. *C. alopecuroides*;
E. *C. nubigena*;
F. *C. teres*;
G. *C. rochebrunii* (All diagrammatic— not after the scale)
Fig. 32. Morphology of stamens of *Carex* L.

A. and B. *C. composita*; C. *C. stramentitia*; D. *C. filicina*; E. *C. setigera*; F. *C. speciosa*.

G. *C. daltonii*; H. *C. nubigena*; I. *C. rochebrunii*

(All diagrammatic - not in scale)
Fig. 33. Morphology of utricles of Carex L.

A. C. baccans; B. C. myosurus; C. C. spiculata; D. C. composita; E. C. cruciata var. argocarpus;
F. C. cruciata var. nagporensis; G. C. burttii; H. C. stramentitia; I. C. filicina (immature)(All
diagrammatic- not in scale)
Fig. 34. Morphology of utricles of Carex L.

A. C. filicina; B. C. continua; C. C. condensata; D. C. inanis; E. C. speciosa; F. C. insignis; G. C. polycephala; H. C. finitima; I. C. alopecuroides; J. C. teres; K. C. longipes; L. C. nubigena; M. C. rochebrunii (All diagrammatic- not in scale).
Plate V. Morphology of utricles and nut of Carex spp. (under SEM)
1. C. baccans- utricle and nut; 2. C. myosurus- utricle; 3. C. breviculmis- utricle surface (apical part); 4. C. setigera- (utricle surface apical part).
Fig. 35. Morphology nuts of Carex L.
A. C. baccans; B. C. myosurus; C. C. spiculata; D. C. cruciata var. argocarpus; E. C. cruciata var. nagporensis; F. C. burtii; G. C. stramentitia; H. C. filicina; I. C. continua; J. C. inanis; K. C. setigera; L. C. breviculmis; M. C. speciosa; N. C. insignis; O. C. polypephala; P. C. finitima; Q. C. alopecuroides; R. C. teres; S. C. longipes; T. C. nubigena (All diagrammatic - not in scale)
Fig. 36. Outlines of culms of *Carex* L. under transverse sections:
A. *C. ruciata* var. *argocarpus*; B. *C. alopecuroides*; C. *C. teres*; D. *C. stramentitia*; E. *C. composita*; F. *C. nubigena*; G. *C. rochebrunii*. (all diagrammatic—not in scale)
Plate VI. Morphology of nuts and nut surface of *Carex* spp. (under SEM)

1. & 2. *C. nubigena*- nut and nut surface; 3 and 4. *C. setigera*- nut surface from apical part and nut surface showing silica bodies (sb-silica body)
Plate VII. Silica bodies in the surface of nuts of *Carex* spp. (under SEM):

Plate VIII. Anatomical features of culms of *Carex* spp. under transverse sections:
(proper magnification given in chapter 5.2)
Plate IX. Anatomical features of leaves of Carex spp. under transverse sections:

1. C. condensata (portion of lamina); 2. C. inanis (lamina); 3. C. condensata (portion of lamina)
4. C. polycephala (lamina) 5. C. nubigena (lamina) 6. C. condensata (laminar groove); 7. C. composita (laminar groove) (proper magnification given in chapter 5.2)
Plate X. Anatomical features of leaves of *Carex* spp. under transverse sections: (All midrib portion showing bulliform cells)

Plate XI. Anatomical features of leaves of Carex spp. under transverse sections (showing different cellular composition:
1. Carex longipes; 2. Carex teres; 3. Carex baccans; 4. C. composita (magnification given in chapter 5.2)
5.2 Morphological and anatomical descriptions of the studied species of *Carex* L.

The genus *Carex* L. has long been recognized under the family Cyperaceae and had been well placed either under a separate subfamily Caricoideae or under the tribe Cariceae. This genus has diverse biogeographical distribution comprising with roughly 40% of the family species as well as making it as one of the largest genera of angiosperms (Reznicek, 1990; Mabberley, 2008). Dai Lunkai *et al.* (2010) had provided the estimation of about 2000 species distributed worldwide. This genus has a good number of representative as about 142 species according to Clarke (1893-1894) from the then Flora of British India. The present estimation is about 163 species from the present day India as stated by Karthikeyan *et al.* (1989) and it is the latest latest information for India. Furthermore, it is further reported that North-eastern region of India is the major centre of distribution of the species of this genus (Clarke, 1893-1894; Rao and Verma, 1992; Karthikeyan *et al.*, 1989). Later Noltie (1994) had mentioned that Sikkim and Darjeeling Himalayan regions along with Bhutan have the maximum concentration as good as 73 species and Sikkim and Darjeeling Himalayas are with 55 species. From the time of Clarke (1893-1894) it was already known the North-eastern Indian regions now consisting of Assam, Meghalaya, Nagaland, Mijoram, Monipur, Arunachal Pradesh, Tripura and the Sikkim and the part of Darjeeling Himalayas have nearly 46 species, 7 to Western Himalaya, 12 to Peninsular India, 5 to Indian desert and 1 to Gangetic plain. Moreover, the estimation of Eastern Himalaya includes Sikkim and Arunachal Pradesh, have 26 species.

The present study is with the collection of 23 species (24 taxa) mostly from the Darjeeling and Sikkim Himalayan regions. These species are placed in the classifications of subgenera and then tribe and the descriptions of each species were done both morphological and anatomical characters. An artificial key to the subgenera is provided. Key to the sections is provided whenever there is more than one and so also for the key to the species. For the studied specimens examined is given under chapter 4 Materials and Methods.

The descriptions, particularly morphological features, were done always based on field observations of a large number of populations to confirm the actual features of habit, habitat, floral arrangement, sex distribution and finally the synflorescence nature of each species.
The correct nomenclature along with synonym and basionym, if present, are provided. The citations of earlier literatures were provided relevant to major works as well as concerning to the study of these biogeographical regions.

Key to the subgenera of Carex L.

1a. Spikes few to numerous, unisexual or bisexual, pedunculate, rarely shortly pedunculate to subsessile, rarely single and terminal, usually loosely arranged in racemose like or paniculate structure of synflorescence, rarely in spicate synflorescence; cladoprophyll present; stigmas usually 3, rarely 2..............................................................................................................................2

1b. Spikes numerous, all bisexual, sessile, usually densely arranged in spicate synflorescence; cladoprophyll not present; stigmas usually 2, rarely 3.......................C. C. subgenus Vignea

2a. Spikes with bisexual and androgynous arrangements of spikelets, very rarely unisexual, usually arranged in complex synflorescence; cladoprophyll utriculiform at spike base, with a female spikelet ................................................................. A. C. subgenus Vigneastra

2b. Spikes with unisexual, or both unisexual and bisexual, rarely all bisexual in arrangement, 1 to several borne in an involucral bract sheath, rarely arranged in complex synflorescence; cladoprophyll sheath-like, without female flower................................. B. C. subgenus Carex


The subgenus Vigneastra is characterized as follows:

Synflorescence simple or compound; spikes few to numerous, usually bisexual and of androgynous arrangement, rarely unisexual; cladoprophyll utriculiform, with or without a developed female flower.

Key to the sections of the subgenus Vigneastra

1a. Spikes cylindric, longer, 2–8 cm long, with numerous spikelets.... I. C. section Polystachyae

1b. Spikes oblong, shorter, less than 2 cm long, with fewer spikelets........ II. C. section Indicae

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The section Polystachyae is known by the following characters as,-
Panicles compound or simple; spikes numerous, bisexual, androgynous, arising from flowerless utriculiform cladoprophylls, cylindric, 2–8 cm long.

Key to the species of the section Polystachyae

1a. Utricles inflated, red to purplish red.................................................................................... 1. C. baccans

1b. Utricles not inflated, pale green to brown.............................................................................. 2

2a. Utricles ovate-globose, flatly trigonous, 3–3.5 mm long, shortly beaked, margins of upper part hairy; female glumes hairy abaxially; sheaths pale brown, persistent................................. 4. C. composita

2b. Utricles obovate-lanceolate, obtusely trigonous, 3.5–4 mm, with beak of medium length, margins of upper part scabrid; female glumes glabrous abaxially; sheaths dark-brown, persistent .............................................................................................................................................................. 3

3a. Inflorescence drooping-semierect; branches few spiked; spikes often single, distantly placed; male portion conical, female glumes pale green, margins membranous and brown
.................................................................................................................................................................................................................................................. 2. C. myosurus

3b. Inflorescence erect, stout, branches few-many spiked; spikes compactly arranged; male portion blunt ended; female glumes brown, margins hyaline............................................. 3. C. spiculata


Description

(Figs. 37–42; Pls. XII-XIV)

Morphology

Vegetative morphology: Perennial, monoecious herb; robust, 60 to 100 cm, or rarely to 120 cm long; caespitose and or rhizomatous, phyllopodic; modules 2-5 per genet or to individual plant. Roots light to deep brown. Stems solid, often loosely tufted, ground level or underground
stems horizontal, stoloniferous, hard, covered with scales; aerial stem (culm) erect, triangular in cross section, glabrous; lower 12-16 cm covered with 3-5 nearly bladeless leaf-sheath in immature condition and on maturity persisting as fibres; bases of leaf-sheath reddish to purplish brown, dark reticulate-fibrillose. Leaves inserted along the lower half of the stem, 5-12(14) in number, forming a conspicuous build up at the base; blades 75 to 95 cm long and 7 to 7.5 mm wide, hardly to greatly overtopping the inflorescence top, flat to inversely W-shaped in cross section; veins 7 to 9 of which two prominent veins on each side of mid-vein, parallel; scabrous to glabrous along margins;

**Reproductive morphology:** Plant monoecious. Flowering stem or culm 60 to 70 cm long, stout, triangular in cross section; angles rounded; much shorter than foliage leaves and basal 2-3 bracts; flowering nodes 5 to 6 per module; leaves 5-12, clustered at base of the culm, absent in the upper half (only bract present) of the stem; bracts leafy, lowers overtopping the inflorescence top; lowest one longest and widest, 45 to 50 cm long (including sheath) and 5 to 6 mm wide; bract-sheath distinct at least to the basal 2-3; sheath 5 to 6 cm long, persistent, covering most of the part of the culm; upper bracts gradually decreasing in length and breadth. Inflorescence 30 to 45 cm long; peduncles more or less congested, gradually decreasing in length, massive. 5 to 6-noded; lower nodes generally with single peduncle; distinct, erect; upper 2-3 sometimes 2-peduncled; 4.5 to 5 cm long excluding lowest portion; lower half of the lower peduncle remain hidden within the bract-sheath; secondary branches of panicles extremely short and all spikes appeared sessile; spikes stiffer, more erect, always top one of each peduncle or secondary branches longest, other comparatively shorter, usually 9(lower) to 7.2 cm long; all androgynous; glumes 30-60 per spike; sterile glume absent; female glumes loosely arranged; male part compact. Pistillate part distinct, comparatively longer, 22 to 32 mm long; 25 to 40-flowered; glumes comparatively longer than utricles, glumes ovate to obovate, acute, obtuse and generally cuspidate 4.5-6 mm long (along with the process), deciduous at maturity; body of the glumes 3.5-4.5 mm long; length of the cuspidae varies from 0.5-2 mm; generally single veined (rarely 2 to 3-veined), with some parallelly arranged lateral striations, olive-brown to dark-brown, with hyaline tip; midrib scabrous; stylar base linear; stigma 3. Staminate part dark-red when young, conspicuous, very compact, comparatively shorter than female part, 12 to 18 mm long; 18-35 flowered; glumes 4 to 5 mm, ovate-lanceolate, 2 to 3 distinctly veined, cuspidate: cuspidae 1-
1.5mm long, reddish brown; stamens 3. Utricles nearly globose, spreading horizontally, 3.5 to 4mm long, further longer at maturity; walls thickened, more or less succulent, not stipitate, spreading, 5 to 7-veined (distinct); surface with ridges and furrows, loosely arranged with the axis, nearly glabrous, rarely obscurely hairy near top, in half-ripe stage, usually olivaceous, glistening or shining red at maturity, sometimes hispidulous along the ridges, abruptly constricted into a beak; beak short, 0.5-0.75mm, unequally bidentate, surface of upper half of utricle covered with some dark coloured glands. Nuts ovoid to ellipsoid, trigonous, pyramidal at the ends, black-deep brown, much narrower than utricle, 2 to 2.5mm long, partially covering the utricle, with reticulate surface.

**Microcharacters (SEM study):** Utricles: Epidermal intercostals cells of utricles at middle and proximal half more or less isodiametric, tetragonal to rectangular in shape; outer wall convex; cells on the distal half tetragonal to rhomboidal, isodiametric; outer wall concave; cells in all the cases thin-walled (membranaceous); coastal region indistinct. Nut surface: cells isodiametric, hexagonal, with single conical silica body; basal platform of the silica body concave, ornamentation of basal body not clear; central body projected, deeply raised, single, rounded with pointed end; absence of secondary silica body or satellite; periclinal wall not distinct.

**Anatomy**

**Culm:** Culm triangular in cross section, with broadly rounded corners and one of the corner concave or invaginated inwards, about 0.5 cm diam. Ground tissue towards the center translucent spongy in nature, without any air cavities. Air cavities only at the peripheral region, oblong in outline, with aerenchyma cells, surrounded by chlorenchyma cells. Assimilatory tissue: chlorenchyma cells well developed, interrupted by air cavities and vascular bundles. Vascular bundles: more than 100 in number, mostly present in peripheral region, commonly in two distinct rows, oval in shape; number of vascular bundles of the row/circle decreases towards the center, embedded within both by chlorenchyma and ground tissue; metaxylems 2 to 6 or more then 6, arranged in triangular fashion (2 side by side and others above the two in a group); in the peripheral region major vascular bundles enclosed with or girdered with the sclerenchyma cells, attached with epidermal layer; peripheral girders baculiform in shape while central sclerenchyma
girder crescentiform in shape; the vascular bundles of ground tissue (minor) with 1-5 cell layers of crescentiform sclerenchyma strands. Sclerenchyma tissues: associated with vascular bundles, forming strands or girder at the periphery and extending upto the epidermal layer; peripheral girders baculiform; central girder resting upon ground tissues deeply crescentiform; other vascular bundles of ground tissue (minor vascular bundles) with 2-3 layer of sclerenchyma cells on both the poles; layers of poles joined with each other by a single layer of sclerenchyma itself; hereby sclerenchyma of vascular bundles join together.

Leaf: In transverse leaves flat-V-shaped often with flanged margins, not cleared dorsiventral; lamina thickest near the keel region and gradually tapering towards margins; apex of margins acute; keel protruding and rounded, terminated by silica or papilla. Epidermis: adaxial cells larger than abaxial cells; cells oblong to barrel-shaped; hinge region made up of 11 cells, of which three cells much larger and longer, bulliform; hinge cells of adaxial side larger and oblong than other cells; cells of both epidermal layers over the sclerenchyma zone quite smaller; adaxial layer thickly cuticularized than abaxial layer. Mesophyll tissue well developed, extending upto epidermal layers, not continuous and interrupted by the presence of air cavities as well as major and minor vascular bundles. Sclerenchyma tissue: associated with the vascular bundles, present on both the poles of vascular bundles and joined by each other with a single layer of sclerenchyma itself; adaxial sclerenchyma of major vascular bundles form a girder; girder securiform to baculiform in shape in adaxial surface but abaxial one crescentiform in shape; minor vascular bundles at the tip portion surrounded by single layer of sclerenchymatosus cells; minor vascular bundles of middle portion with abaxial girders. Air-cavities: long-rectangular to oval in outline with translucent, comparatively larger, thin-walled, polygonal, aerenchyma cells. Vascular bundles: arranged in single row, 12 in each half of lamina, 5 to 6 minor and others major and/ or major and minor vascular bundles arranged alternately; each vascular bundle with 2-3 large metaxylems, 2 of them present side by side and others above the two. Sclerenchyma cells: present on both sides of the vascular bundles; vascular bundles oval in shape and equidistant from epidermal layers; bundle sheath cells double-layered, outer layer parenchymatous; inner layer sclerenchymatous; interrupted by sclerenchyma cells on both adaxial and abaxial sides. Bulliform cells present only in the adaxial side.
Fig. 37. Habit and inflorescence of Carex baccans
A. Habit; B. Inflorescence (in part-diagrammatic).
Plate XII. Photographs of habit and infructescence of Carex baccans

Fig. 38. Inflorescence and floral arrangements of *Carex baccans*

A. Inflorescence and floral arrangement; B. Floral arrangements in single spike.

- Male flower, Female flower, Sterile flower
Fig. 39. Morphology of female glumes and utricle of *Carex baccans*

A. 1st female glume; B. 2nd female glume; C. Female glume from middle portion of spike; D. Female glume from terminal portion of spike; E. Utricle.
Fig. 40. Morphology of utricle, nut and male glumes of *Carex baccans*

A. Utricle (showing surface feature); B. Nut; C. 1st male glume; D. 2nd male glume; E. T. S. of nut.
Plate XIII. Scanning electron microphotographs of utricle and nut of Carex baccans

1. Utricle and nut; 2. Utricle surface(distal); 3. Utricle surface(proximal); 4. Nut surface; 5. Nut surface magnified. (sb= silica body)
Fig. 41. Anatomical features of culm of Carex baccans

A. T.S. of culm (diagrammatic); B. Cellular details of culm (in part).
Fig. 42. Anatomical features of leaf of *Carex baccans*

A. T. S. of lamina (diagrammatic); B. Laminar groove (cellular); C. Laminar lateral part (cellular); D. Laminar edge (cellular).
Plate XIV. Microphotographs of anatomical features of culm and leaf of *Carex baccans*

1. T. S. of culm; 2. T.S. of culm (-portion magnified); 3. T.S. of lamina; 4. Laminar groove; 5. T.S. laminar-lateral portion; 6. T.S. of laminar-margin. Scale bars- 1, 3 (300μm); 2, 4-6 (200 μm).

Description (Figs. 43-47; Pls. XV-XVII)

Morphology

Vegetative morphology: Perennial herb, 60 to 90cm, rarely to 120cm long, caespitose and or rhizomatous, phyllopodic, 5-7 modules per genet/plant, loosely to moderately tufted. Roots light brown to deep brown, tomentose. Stems underground and ground level generally rhizomatous, rarely stoloniferous; stolons very short, 1.5 to 2.5cm long, obliquely horizontal, stout, hard; stems of above ground part clothed with the remains of the previous year’s leaf-sheaths; sheaths loosely covered, slightly spongy, reddish to purplish brown, dull, reticulately fibrilloose, sometimes persisting having numerous deep brown fibres. Leaves in basal tufts of 8-12 on the basal 1/3rd -1/4th of the aerial stem; leaves 2-3 on the upper half of the stem; leaf-blades existing for a single season; sheath generally persistent in older part; bladeless sheath in mature part of the stem; bladeless leaves 3-5, reddish brown; sheath in immature plant breaking down into fibrils at maturity; blade coarse, often as long as stem to slightly or greatly exceeding the stem, 65 to 80cm long and 0.5 to 1.5 cm wide.

Reproductive morphology: Plant monoecious. Culms 45-75cm long, acutely triangular in cross section, much shorter than the foliage and basal 3-5 bracts; flowering nodes 4-9 per module; lowest node very distantly placed; upper half of the culm with 2-3 distantly placed leaves; bracts leafy; lower 4-5 bracts alike to foliage, greatly overtopping the inflorescence top; lowest bract longest and widest, 30 to 45cm long and 4 to 5 mm wide; upper bract gradually decreasing in length and breadth, ultimately becoming filiform; bract-sheath distinct, gradually decreasing in length upward; lowest bract-sheath 5 to 7.5 mm long; all persisting and partially covering the culm. Inflorescence 40 to 60cm long (excluding culm), massive, with paniculate appearance, slightly drooping at maturity; peduncles 1-3 to each node; lower node always with single peduncle; upper 2-3 nodes sometimes with 2-3 peduncles; lowest peduncle longest. 3 to
5cm long; upper peduncles gradually decreasing in length; spikes 3-9(12) per node; immature inflorescence as whole unit remaining hidden or fully covered within sheath; spikes spacey; secondary inflorescence axis or the panicle not developed at all or extremely short; all spikes appearing sessile; individual spike comparatively weaker, drooping, 2.5 to 6.5 cm long; top most spike always longest, gradually decreasing in length towards base; spikes 30 to 90(125) flowered, all androgynous; sometimes sterile glume present at the base and middle of the spike; sterile glumes rarely 15-30, generally 1-3; female glumes lax; male glumes compact. Pistillate part conspicuous, variable in length, comparatively longer, 1.5 to 4.5cm long, sometimes as long as male portion, 15 to 75(80)-flowered; femaleness increases with the increase of the length of spike; female glumes as long as utricle, 2.8 to 3.5mm long(excluding the appendage), ovate-oblong to lanceolate, acute- apiculate to mucronate, olive-brown to dark-brown, margins and tips hyaline, single-veined, sometimes with some incomplete indistinct veins at base of female glume; midrib scabrous; sometimes very shortly 0.5 to 0.7mm long, excurrent, often cuspidate; style short, linear, base not dilated, 0.5 to 0.7mm long; stigmas 3, comparatively longer, 2.5 to 3.0mm long, generally not curved, projected. Staminate part of spikes conspicuous, very short to equaling the female portion, linear-cylindrical, 8mm to 3.5cm long, 10 to 55-flowered, glistening reddish brown when young, blackish brown at maturity; male glumes narrowly oblanceolate to ovate, 3.5 to 5mm long; midvein distinct, 1-veined; other veins 4-5, inconspicuous, parallelly arranged on each side of midvein, tapered at apex to very shortly excurrent midrib, reddish brown; stamens 3; filaments as long as male glume at maturity, 5 to 6mm long; anthers linear-oblong, appendiculate crested, not bristled. Utricles obovoid- narrowly ellipsoid, trigonous, loosely arranged (lax) at maturity, 2.7 to 3.4mm long, distinctly 7-9-veined, some gatherings with 15-17 indistinct veins, gradually narrowed towards apex into a short beak of 0.5-0.9mm long; beak distinctly bifid, serrulate on strongest ribs and margins; upper part glabrous to shortly hispidulous, olive-green, suffused brown to varying degrees. Nuts ovoid to ellipsoid, trigonous (triangular in cross section with rounded angles), slightly stipitate, closely fitting/filling the utricle, 2.2 to 2.7 mm long, light to dark brown, surface reticulate and with ornamentations.

**Microcharacters (SEM study):** Utricle: Epidermal intercostal cells on the distal 1/3rd of the utricle, particularly at the junction of beak and body polygonal in outline; outer walls concave; anticlinal walls raised; cells of the proximal 2/3rd of the utricle inconspicuous. Nut
surface: Cells polygonal, mainly hexagonal or rarely pentagonal, rarely with single central silica body per cell; basal body/basal platform of the silica body concave; ornamentation of the basal body not clear; central body of the silica slightly/faintly raised in some cells, sometimes not distinguishable; absence of radiating bars in central body and basal platform; devoid of satellite body; apex of the central body not pointed; cells at the distal end of the nut polygonal, difficult to find out the central body of silica, basal platform and satellite body; all cells devoid of silica body.

Anatomy:

Culm: In transverse section culm triangular with sub-acute corners, specimen studied about 0.8 cm long. Epidermis wavy. Ground tissue towards the center, translucent, spongy in nature. Air cavities absent. Assimilatory tissue: chlorenchyma tissues arranged in peripheral region; cells somewhat rounded, smaller in size in comparison to the ground tissue cells; cells well developed around the minor vascular bundles. Vascular bundles: mostly 70-75, scattered in peripheral region and less towards center, forming two complete rows or circle and one incomplete circle or row; cells of peripheral region dense and with adaxial sclerenchymatous girder: major and minor vascular bundles arranged alternately, with sclerenchymatous cells on both sides of vascular bundles; all bundles oval to rounded in shape and with 2-3 large metaxylem, having sclerenchyma cells on both sides; peripheral major vascular bundles with adaxial sclerenchyma forming girder, triangular to baculiform in shape; layers of cells ranging from 3-4 in central portions and above 12 in peripheral girder; central vascular bundles surrounded by sclerenchyma of 2-4 layers. Sclerenchyma tissues: in association of vascular bundles, sometimes interconnected with each other; patches of sclerenchyma present opposite to the minor vascular bundles and not connected with any of the vascular bundles.

Leaf: in transverse section inverted W-shaped, often flanged margined, having median groove in keel, dorsiventral; lamina thick at the keel portion and intermediate between the margins and the keel region, gradually tapering towards the margins; margins of the lamina sub-acute; keel prominent and rounded, 0.9-1.2 cm thick. Epidermis: cells of adaxial surface larger than the cell of abaxial surface; cells barrel-shaped, variable in size in both the epidermal layer, quite smaller at the region of attachment of sclerenchymatous girder; cuticular layer thick over
the adaxial surface and comparatively thin on abaxial surface; hinge cells 11-12, single cell layered, smaller, or more or less equal to the other epidermal cells. Mesophyll tissue: chlorenchymatous, cell well developed and extend from adaxial epidermal layer to abaxial epidermal layer and interrupted by the presence of air cavities and vascular bundles; chlorenchymatous cells well developed around the air cavity; cells oval to barrel-shaped. Sclerenchyma tissue: associated with the vascular bundles, placed on both sides of vascular bundles, in hinge portion sclerenchyma forming girder, extending up to the epidermal layer on both surfaces; abaxial portion crescentiform and adaxial as cap of 2-3 cell layers; keel portion with sclerenchymatous girder extending in both to abaxial and adaxial sides and connected with the layers; adaxial girder T-shaped and abaxial one winged, crescentiform; sclerenchyma tissue of 7 cell layers in minor vascular bundles also in the vascular bundle of tip portion; patch of sclerenchyma present with the vascular bundle in adaxial portion just above the terminal vascular bundle and attached with the upper epidermis. Air-cavities: rounded to nearly tetragonal/4-angular in outline, with cell layer; cells translucent, thin-walled, tetragonal to oblong in shape; cavities surrounded by chlorenchyma cells and the cells comparatively larger, thin-walled, polygonal. Vascular bundles: arranged in single row, 15-17 in each half of the lamina; 7 major and the rests minor; minor vascular bundles at the middle of the adaxial and abaxial epidermal layer; major bundles attached with both epidermal layers by a sclerenchymatous girder: major and minor vascular bundles arranged alternately and equidistant from adaxial and abaxial epidermal layers; each vascular bundle with two pairs or three pairs of metaxylem; minor vascular bundles surrounded by 1-2 layers of sclerenchyma tissue; bundle sheath cell double-layered; outer parenchymatous and inner sclerenchymatous and interrupted by the sclerenchyma tissue.
Fig. 43: Habit and inflorescence of Carex myosurus
A. Habit; B. Inflorescence (diagrammatic in part); C. Arrangement of flowers on spike.
—Male flower, —Female flower, —Sterile flower

Male flower, Female flower, Sterile flower
Plate XV: Photographs of habit and inflorescence of *Carex myosurus*

1. Habit of mature modules; 2. Spikes (magnified) with androgynous floral arrangement.
Fig. 44: Morphology of female glumes, female flower, utricle and nut of *Carex myosurus*

A. 1st female glume; B. 2nd female glume; C. Female flower with style and stigma; E. Utricle (intact); F. Utricle (split open); G. Nut.
Fig. 45: Morphology of nut, male glume and stamens of *Carex myosurus*

A. T. S. of nut; B. Male glume from basal part of spike; C. Male glume from upper part of spike; D. Stamens.
Plate XVI. Scanning electron microphotographs of utricle and nut of *Carex myosurus*

Fig. 46. Anatomical features of culm *Carex myosurus*

A. T.S. of culm (diagrammatic); B. A portion of culm (cellular).
Fig. 47. Anatomical features of leaf of Carex myosurus

A. T.S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral part(cellular);
D. Laminar edge(cellular).
Plate XVII. Microphotographs of anatomical features of culm and leaf of Carex myosurus

1. T.S. of culm; 2. A portion of culm magnified; 3. T.S. of lamina; 4. Laminar groove; 5. Laminar lateral portion; 6. Laminar edge. Scale bar-1, 3 and 6 (300 µm); 2, 4 and 5 (200 µm).

Description (Figs. 48-52; Pls. XVIII-XX)

Morphology

Vegetative Morphology: Perennial herb, to 120cm(130cm) long; caespitose of 5-7 modules, modules rarely up to 12 per plant/ genet, moderately to loosely tufted. Roots variable, dark brown to light brown, tomentose or not. Underground rhizomes short, thick, very hard, sometimes stoloniferous; stolons horizontal, 7.5-9.5 cm long, uneven in thickness, 10-12-noded, ribbed, covered with shiny, deep brown scales of fibres; above ground stem clothed at base with the bases of both leaf-sheaths and bladeless sheaths; bladeless sheath prominent, 3-5, dark brown to purplish brown; bases of leaf-sheaths faintly to strongly ribbed, bases of leaf-sheaths and bladeless sheaths breaking down into elongated, dull fibrils at maturity; mouth of leaf-sheath also breaking down into reticulate fibrils; sheath of leaf bases form a conspicuous built up at the base of aerial stems and culms. Leaves in basal to sub-basal tufts, 7-13, rarely 20-22 on the basal half of the culm, 2-3 (4) foliage on the upper half of the culm; blades well developed, strong and wide, variable in length, nearly reaching to greatly overtopping the inflorescence top, 75-95cm(110 cm) long and 0.9 -1.5cm wide, margins coarse, strongly scabrous; midvein single and with 9-12 parallel secondaries on each side of the midvein; linear to inverted W-shaped in cross section at middle.

Reproductive morphology: Plant monocious. Culm 65-110cm long; more or less shorter to hardly equaling the leaves; flowering nodes 5-7, sometimes reaching up to 11 per module; basal 1-3 nodes with 8-12 (20-22) leaves clustered at the base of the culm; 4-5 nodes of the upper half of the culm with 4-5 distantly placed leaves; bracts all leafy, basal in position to inflorescence; lower bracts alike to leaf-blades, slightly to greatly overtopping the axis, 50-90cm
long and 0.5-0.9cm wide at the middle; sheath of bracts well developed, persistent; lowest one 6-12cm long; in upper nodes gradually decreasing in length and breadth, surface carioceous; cladophyll absent. Inflorescence of multiple spikes on solitary culm; spikes 3-12 on each peduncle (per node); peduncles long, lowest one 4.5-5.5cm long; lateral spikes on very short stalk or sub-sessile; number of spike highest at the middle nodes than the basal upper nodes of the modules; length of spikes highest at the middle of the inflorescence, to 5.5cm long; spikes distichous, sub-erect to erect, strong, not divergent or drooping, linear to linear-oblong in outline; spikes of lower part shorter, 2.5-3.5cm long; spikes of middle part comparatively longer. 6.5-7.0cm long; spikes of upper part again shorter; all androgynous, with usually 40-120 to rarely 150 florets per spike; basal 2-3 glumes sterile; all the glumes closely set and spreading at maturity. Pistillate portion distinct, 1.5-4cm long, 60 to 80(90)-flowered; female glumes comparatively longer than the utricle, 3.5-4mm long, persistent; lower 2-3 glumes sterile; ovate, comparatively smaller, slightly apiculate (with appendages), distinctly single veined with 4-5 stripes on each side of the midvein on the upper half of the glumes, light to dark brown, slightly hispidulous along the midvein, margins and at the apex; style homogenous (slightly bulbous), comparatively shorter 0.9-1.4mm long; with projection; stigmas 3, comparatively longer at maturity, 1.8–2.5mm long, surface muricate. Staminate portion conspicuous, well developed, compact, with variable sizes, sometimes comparatively shorter than the pistillate part, or sometimes more or less equal to or sometimes comparatively longer than the pistillate part; maleness increases with the increase of the spike length, 0.5-3.5cm long, 40-60-flowered; longest spike with half male and half female, shorter spikes with 1/3rd - 1/4th portion male; glumes ovate to oblong to ovate-elliptic, 4.5-5.5mm long, slightly apiculate, bristled at the apex, distinctly 1-midveined; indistinct veins 4-5 on each side of the midvein, incomplete; stamens 3; filaments comparatively longer than anthers, 3-4mm long; anthers linear, more or less equal to filament or shorter, 2-3mm long; crests slightly apiculate, without any projection. Utricles ellipsoids, 3.5-4mm long at maturity, distinctly stipitate; stalk 0.5 -1mm; loosely attached with the axis, spreading, 5 to 7(10)-veined; upper half of the utricle and beak hispidulous; beak short, as 0.75-1mm long, distinctly bidentate, coriaceous, pale green colored. Nuts ellipsoid to obovoid; triangular in cross section, 3-3.5mm, fully covering the utricle, with reticulate surface, dark brown to black.
Microcharacters (SEM study): Utricle: intercostal and costal cells differentiation prominent; cells at the proximal end thin-walled, rectangular in outline, outer wall sometimes convex or sometimes concave. Nut surface: cells at the middle part of nuts without clear cellular appearance and walls having single prominent silica body; basal platform of silica body convex, devoid of any ornamentation on basal platform; central body of the silica distinctly raised, conical with pointed end, devoid of satellite body/secondary silica body; cells of the beak region rectangular to barrel-shaped, gradually decreasing in length towards the stylopodium; cells of the stylopodium mostly polygonal, isodiametric and more congested.

Anatomy

Culm: triangular in cross section having rounded corners, with translucent ground tissue towards center. Air cavity absent in the ground tissue, present only at the peripheral region, oblong to irregular in outline, with rounded-oval aerenchyma cells within; air chamber surrounded by chlorenchyma cells. Assimilatory tissue: chlorenchyma cells at the peripheral region. 5-6 cells layered thick, often interrupted by the presence of aerenchyma, vascular bundles and sclerenchyma tissue. Vascular bundles: more than 70, single row in peripheral region and others scattered towards the center, embedded on ground tissue, oval, with 2-4 large conspicuous large metaxylems, triangular in outline; sclerenchyma on both sides of vascular bundles. Sclerenchyma tissue: in peripheral region forms girders joined with the epidermis, baculiform in shape and adaxial ones securiform to crescentiform; in minor vascular bundle sclerenchyma forms layer around the vascular bundles.

Leaf: In transverse section leaves inversely W-shaped, often flanged; keel prominent, acute; dorsiventral, tapered towards apex, acute at apex, terminated by silica/papila. Epidermis: adaxial epidermal cells larger than abaxial cells; the cells at the region of the attachment of sclerenchyma girders comparatively smaller in both sides, oblong, in hinge portion the adaxial epidermal cells 9-10, single cell layered; hinge cells comparatively larger. Mesophyll tissue: chlorenchyma cells well developed, interrupted by air cavities, vascular bundles and sclerenchyma tissue. Sclerenchyma tissue: associated with vascular bundles and present on both sides of vascular bundle; major vascular bundles with girder at both sides; girder attached with adaxial and abaxial epidermal cells; girder shape baculiform to adaxial side and securiform to...
abaxial side or sometimes crescentiform; sclerenchyma 1-2 cell-layered encircled major vascular bundles. Air cavities: oblong in outline, oval-shaped; cavity surrounded by chlorenchyma cells. Vascular bundles: 15-18, in one half of the lamina; both major and minor vascular bundles arranged alternately, oval, with 2-3 metaxylems. Sclerenchyma tissue: associated and surrounding vascular bundles; the minor vascular bundles crowded and surrounded by single layer of sclerenchyma cells, sometimes on abaxial side of minor vascular bundles a small girder of sclerenchyma present; bundle sheath 1 to 2 cell-layered, outer parenchymatous and inner sclerenchymatous, interrupted by sclerenchyma cells on both sides. Bulliform cells present at the adaxial portion with bulged epidermal cells, rounded in shape; in hinge portion single-layered, rounded.


Description (Figs. 53-57; Pis. XXI-XXIII)

Morphology

Vegetative morphology: Monoecious, perennial herb; 65 to 75cm high, caespitose, with 12-15 modules; stems solid. Roots yellow, tomentose and pallid brown. Underground and ground level stems horizontal to obliquely horizontal, stoloniferous, branched or unbranched, hard, elongate, 15-20cm long, solid, differentiated, nodulated, covered with light brown fibrous scales; aerial stems erect, triangular in cross section, angles rounded, glabrous. Leaves in close basal tufts, 5-7 (9), 15 to 17cm from soil surface, 3-4 on culm on upper part, existing for a single season, longer than the stem, 45-58(65 cm) long and 3 to 5mm wide, single midveined with 4-5 prominent and stronger secondaries; basal bladeless sheath 3-4, rarely 7 or 8, whitish brown to light brown; sheath persistent and breaking down into reticulate, adpressed fibrous covering at the base of the stem, reddish brown.
Fig. 48: Habit and inflorescence of *Carex spiculata*

A. Habit; B. Inflorescence (diagrammatic in part); C. Arrangement of flowers on spike.

- Male flower
- Female flower
- Sterile flower
Plate XVIII. Photographs of habit and inflorescence of *Carex spiculata*

1. Habit and habitat; 2. Spikes (magnified) with androgynous arrangement.
Fig. 49. Morphology of female glume, female flower and utricle of Carex spiculata
A, B: Female glumes; C. Utricle with style and stigma; D, E. Utricles.
Fig. 50. Morphology of nut, male glumes and filaments of *Carex spiculata*

A. Nut; B. T. S. of nut; C. Male glume- side view; D. Male glume with filaments (anthers detached).
Plate XIX. Scanning electron microphotographs of utricle and nut of *Carex spiculata*

Fig. 51. Anatomical features of culm of *Carex spiculata*

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 52. Anatomical features of leaf of Carex spiculata
A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral part(cellular); D. Laminar edge(cellular).
Plate XX. Microphotographs of anatomical features of culm of *Carex spiculata*

1. T.S. of culm; 2. A portion of culm (magnified) 3. A portion of culm showing distribution of sclerenchyma tissues and vascular bundles. Scale bar-1(300µm); 2(200 µm); 3(50 µm).
Reproductive morphology: Plant monoecious. Culms shorter than the leaves; flowering nodes 5-7 per modules; 2-3 leaves on the upper half of the culm, glabrous; bract leafy, associated with the base of the inflorescence, exceeding the inflorescence and gradually decreasing in length; lowest one 30-45 cm long having shorter sheath than the blades; lowest sheath longest, 12-15 cm long, persistent; lower bracts (2-3) foliaceous; upper bristle like or capillaceous. Inflorescence spicate, linear to oblong in outline, 15-30 cm long and 2-4 cm wide; peduncles one per node; hidden within the sheath when young, slightly emerging (1mm long) at maturity, glabrous; inflorescence multispicate, 9-17-spiked; terminal spike sometimes with basal minute spike; individual spike always erect, both when young and at maturity; all spikes androgynous, 30-80(100) glumes per spike; sterile glumes absent; flowering glumes very compact at maturity. Staminate part inconspicuous 3-18mm long, 3-40(45)-flowered; maleness increases with the length of the spike; staminate glumes inconspicuous, comparatively larger; 4.25-5mm, single-veined, oblong-lanceolate, acuminate, with bristled tip, lateral portion stramineous, red-streaked; middle portion light green to hyaline; stamens 3, unequal; anthers linear-oblong, 2-2.25 mm long; anther crests apiculate with a fimbriate projections. Pistillate part 3-5mm long, 8-75-flowered; glumes ovate, 3-3.25mm long, slightly aristate-acuminate, bristled, stramineous, red-streaked, 5-7-veined (sometimes one); 3 veins complete and 2-4 veins incomplete; number of veins gradually decreases and fixed into one on upper side, not early falling; style 1-1.25 mm long, with dilated/bend at base; stigmas 3, 2-2.25 mm long, with fimbriate projection. Utricles shortly stipitate, membraneous, broadly ovoid to subglobose, compressed-trigonous, 2.5x1.5 mm; compact or obliquely spreading at maturity, villose; upper half green when young, reddish brown to reddish at maturity; lower half whitish at maturity, appearing veinless, not keeled, constricted trigonous in transverse section; apices abruptly constricted into short beak; beak 0.3-0.5mm long, distinctly bidentate. Nuts hardly filling the perigynia, ellipsoid, 1.75-2.0 mm long, trigonous, sessile and brown to blackish.

Microcharacters (SEM study): Utricle: Epidermal both intercostals and costal cells rectangular; outer walls of cells concave; costal cells much longer than the intercostals. Nut surface: made up of mostly polygonal cells, rarely penta-gonal and hexa-gonal; silica body single, central, distinctly raised; basal platform of silica body deeply concave; central body of silica
slightly raised with pointed apex; basal plate without any ornamentation; secondary silica bodies absent; silica bodies not clear on basal 1/3 part of the nut or of rare occurrence.

Anatomy

Culm: Triangular in cross section with broadly rounded corners to slightly round corners; epidermis sometime wavy; specimen examined 0.2 to 0.3 cm length; central ground tissue translucent, spongy. Air-cavities: present at peripheral region within the chlorenchyma tissue, square to oblong in outline with oval to oblong translucent aerenchyma cells within it. Assimilatory tissue: chlorenchyma cells well developed at the peripheral region; thick-layered on the outer face of air cavities and thin on the other face. Vascular bundles: about 100, scattered throughout or in 3-4 concentric rings; one row of vascular bundle embedded within chlorenchyma tissue and others scattered in the ground tissue; 40-42 vascular bundles at peripheral row; each with 2 or more than two large metaxylems, elliptical or rounded in shape. Sclerenchyma tissue: associated with vascular bundles, in some vascular bundles of periphery forming girders, baculiform in shape; others vascular bundles having crescentiform cap on both sides of the vascular bundles.

Leaf: Leaf inverted W-shaped in cross section, margins often flanged, lamina thick at the keel portion or area and tapering towards the margins; tip of the margins slightly rounded; studied specimen 0.4-0.5 cm long; keel protruding and rounded. Epidermis: adaxial cells much larger than abaxial cells; cells over sclerenchyma strands quite smaller in both the cases; cells of hinge portion 2-layered; first layer with 13-14-celled and second layer 21-22-celled; hinge cells much more longer than the other epidermal cells. Mesophyll tissue: well developed, surrounding the air cavities and minor vascular bundles. Air-cavities: large rectangular in outline with rounded corners with translucent oblong aerenchyma cells within it. Vascular bundles: 9 in number in each half of the lamina; major vascular bundles 4-5 and remaining minor; minor vascular bundles near to the adaxial epidermal layer and major ones in middle of the two epidermises; vascular bundles in single row, oval in shape and sclerenchyma cells on both the poles of vascular bundles; with 2 or more than 2 meta-xylems, arranged in triangular fashion (2 single, side by side and the other above the 2 in single group). Sclerenchyma tissue: associated with vascular bundles: in adaxial surface of median vascular bundle forming a girder, ascending crescentiform in shape.
but having abaxial cap; the abaxial sclerenchyma of keel portion baculiform to Y-shaped and adaxial sclerenchyma crescentiform; in minor vascular bundles 1-2 cell-layers of sclerenchyma surrounding the vascular bundles; in the adaxial portion of the margins, a patch of 6-8 cell-layered sclerenchyma connected with adaxial epidermal layer. Bundle sheath 2 cell-layered, outer parenchymatous and inner sclerenchymatous; interrupted by sclerenchyma cells in major vascular bundles but completely circular in case of minor vascular bundle of tip portion. Bulliform cells: present only on the adaxial epidermal layer.
Fig. 53. Habit and inflorescence of *Carex composita*

A. Habit; B. Inflorescence (single node only); C. Inflorescence (diagrammatic, with arrangement of flowers).

- **Male flower**
- **Female flower**
- **Sterile flower**
Plate XXI. Photographs of habit and inflorescence of *Carex composita*

1. Habit; 2. Inflorescence (semi mature spikes).
Fig. 54. Morphology of female glume, female flower and utricle of *Carex composita*

A. Female glume of base; B. Female glume from middle; C, D. Female glume from top of the spike; E. Female flower; F. Utricle.
Fig. 55. Morphology of utricle, male glume and stamens of Carex composita
A. Utricle; B. T.S. of nut; C, D. Male glumes; E. Stamens; F. Anther crests(enlarged).
Plate XXII. Scanning electron microphotographs of utricle and nut of Carex composita

Fig. 56. Anatomical features of culm of Carex composita
A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 57. Anatomical features of leaf of *Carex composita*

A. T. S. lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral part(cellular); D. Laminar edge(cellular).
Plate XXIII. Microphotographs of culm and leaf of *Carex composita*

1. T. S. of culm; 2. A portion of culm magnified; 3. T. S. of lamina; 4. Laminar groove; 5. Laminar lateral portion; 6. Laminar margin. Scale bars-1, 3 (300 μm); 2, 4-6 (200 μm).

The section Indicae is characterized by the following features:

Panicles compound; spikes numerous, bisexual, androgynous, arising from flowerless utriculiform cladoprophylls; oblong, less than 2 cm long, utricles not inflated, or slightly inflated, many-veined.

Key to the species of the section Indicae:

1a. Beak of utricles deflexed/reflexed, comparatively longer and not bidentate (with oblique aperture); both the female glumes and utricle with blackish brown unique glandular spots ................................................................. 8. C. filicina

1b. Beak of the utricle straight, comparatively shorter, bidentate; female glumes and utricles not glandular........................................................................................................................................... 2

2a. Leaf-sheath and body of both the male and female glumes with pale brown streaks; leaf-blades much wider; immature inflorescence typical cream-colored, tip of female glumes muticous; anther crests distinct.................. ...................................................... 7. C. stramentitia

2b. Leaf-sheath and body of both the male and female glumes not streaked; leaf-blades less wide; immature inflorescence green; female glumes not muticous; anther crests not distinct...... .......................................................................................................................................................... 3

3a. Panicle pyramidal; male and female portions of the spike more or less equal in length .......................................................................................................................................................................................... 5. C. cruciata

3b. Panicle linear, obling-elongated (not pyramidal); male and female portions of the spike unequal in length.......................................................................................................................................................... 4

4a. Number of female flowers much more in comparison to number of male flowers; terminal portion of spike represented by very few male flowers, spikes very distantly placed, never in groups................................................................................................................................. 9. C. continua

4b. Number of female flowers less in comparison to number of male flowers; terminal portion of spike with more male flowers; spikes arising in group of 3-9(12) ...................................................... 5

5a. Spike(s) long, linear, 5-12 in groups, 5-12mm long, shining brown to reddish brown ............................................................................................................................................................................. 10. C. condensata

5b. Spike(s) short, ovate- elliptical, 3-5 in groups, longest one 6-7mm long, pale-brown .............................................................................................................................................................. 6. C. burttii

**Key to the varities of Carex cruciata:**

1a. Mature utricles glistening white, often infected by smut fungi; vegetative phase comparatively shorter; female glumes more broader and more hispidulous at apex; beak of utricle more hispidulous ................................................................. 5a. *C. cruciata* var. *argocarpus*

1b. Mature utricles greenish-pale brown, never infected by smuts; vegetative phase robust; female glumes less broader and less hispidulous at apex; beak of utricle less hispidulous ................................................................. 5b. *C. cruciata* var. *nagporensis*


**Description** (Figs. 58-61; Pls. XXIV- XXVI)

**Morphology**

Vegetative morphology: Perennial herb, 60 to 120 cm high, caespitose, phyllopol: modules 3-5 per plant/genet, loosely tufted. Roots light brown (younger), tomentose and deep brown (older). Stems underground and at ground level horizontal, stoloniferous, stout, hard, clothed at apex with remains of old leaves (particularly with leaf-sheath); leaf-sheaths loosely covered, spongy, pale brown, not breaking, not fibrillose; fibres not persisting; scales absent on
stolons; root also emerges from stolon at the ground; new plantlets developed from attachment site; root sometimes present on aerial stem, 10-20 cm above the ground level. Leaves in basal tufts, 7-13; blades existing for a single season; sheath generally persistent in older part; basal leaves 4-5, bladeless in case of immature plantlets, reddish brown, persisting, ensheathing, not breaking down into fibres and along the leaf-sheath and forming a conspicuous build up at the base of the plant, or leaf-sheath fibrillose in 2-3 years older plants; leaves of sub-basal and on lower half of the culm with blades of 55 to 90 cm long and 6 to 9 mm wide, straight, linear, inverted W-shaped in cross section, greatly exceeding the inflorescence top; midvein one and lateral 2-3 secondary veins, all prominent, or 3-4 nearly prominent, parallel secondaries; margins scabrous.

Reproductive morphology: Plant monoecious. Flowering stem (culm) 60 to 90 cm long, much shorter than the leaf blades and lower few bracts, leafy on the upper half, 6-9 in flowering nodes per module; bracts leafy, closely associated with the base of the inflorescence, lower 2-3 alike to foliage leaves, greatly exceeding or overtopping the inflorescence top; lowest one longest, 50 to 65 cm long and 5 to 7 mm wide, surface scabrous; bract-sheath distinct, lowest bracts 10 to 12 mm long, covering the lower part of the peduncle; in upper nodes the bracts (sheath and blades) gradually decreasing in length and width, eventually become filiform; all bracts persistent. Inflorescence massive, paniculate, 20 to 50 cm long, narrowly cylindric; partial panicle inserted singly per node; spikes numerous, narrowly pyramidal; branchlets and spikes evenly spacing; bracteoles ( cladophyll) present; individual spike all androgynous, short. longest one 10 to 12 mm long, predominantly female with upper few(4-5) male flowers; female flowers 10-12 on longest spike; female portion 5 to 10 mm long; male portion 2 to 4 mm long, probably protogynous; spikes ovate-linear to oblanceolate in outline; basal flowers 2-3 often distinctly placed, sterile; female flowers spreading on maturity; male portion in close set. Pistillate portion 5 to 8 mm long, 5-10(12)-flowered; female glumes as long as utricles, or much shorter than utricle. 2.5 to 3 mm, ovate, slightly mucronate, with bristles, 2-3-distinctly veined, with some pale orange-colored streaks on both the surfaces of the midvein, light brown to red-brown, glabrous except the apex, ferruginous; stigmas 3. Staminate part comparatively shorter, 2 to 3 mm, 4-7-flowered; flowering glumes ovate-elliptic, 1-veined, acute, ferruginous, glabrous; stamens 3; filaments much longer (2 to 2.25 mm) than anthers (1.25 to 1.5 mm); anthers linear to linear-oblanceolate.
without any projection. Utricles spreading at maturity, appearing much thickened at maturity. ovate, trigonous, 2.5 to 3.0 mm long, not stipitate, 3-5-veined, prominent in fruiting panicle. scarcely inflated, lower 2/3rd portion quite glabrous, minutely scabrous towards neck; abruptly constricted into a straight beak; beak conspicuous, 0.75 to 1.25 mm long, minutely hispid; beak aperture oblique; utricles at maturity glistening white. Nuts ellipsoid-ovoid, trigonous, 1.75 to 2.5 mm long, triangular in cross section at middle, fitting pretty closely utricle; substipitate. dark-brown.

**Microcharacters (SEM study):** Utricles: Epidermal intercostal cells of basal 1/3rd of utricle rectangular; costal cells at the ridge more distinct than intercostals region; costal region 5-6-celled, distinct; outer wall of intercostals cells concave; intercostals cells of the distal 2/3rd of utricle also rectangular, outer walls concave; costal and inter costal cells both differentiated in this species in comparison to other species of *Carex*. Nut surface: cells at the proximal end rectangular to polygonal in outline, more elongated than the distal and the median region; cells at the middle and distal portion polygonal to mostly hexagonal having single silica body per cell; basal platform of the silica body concave, with ornamentation; central body of silica distinctly raised, pointed with radiating bars; absence of satellite bodies or secondary silica bodies; devoid of periclinal walls; apex cells polygonal, convex, devoid of silica body, without central body, satellite and basal platform.

**Anatomy**

Culm: In transverse section the culm obtusely triangular; the edges or the corners rounded; without papillate extension in epidermis; Specimens examined 0.5 cm long. Chlorenchyma cells present in the peripheral region; translucent ground tissues towards the center; cells of the ground tissue oval to polygonal, larger in size than the peripheral cells. Air cavities: present only in the peripheral chlorenchymatous region, absent in the ground tissue: air chambers oval to rectangular in outline, arranged alternately with the vascular bundles and sclerenchyma girder; aerenchyma cells rectangular to nearly square. Assimilatory tissue: chlorenchymatous at the peripheral region with the cells ranging as oval to oblong; chlorenchyma layer interrupted by the vascular bundles and sclerenchymatous girder. Vascular bundles: scattered throughout the ground tissue and the chlorenchyma tissues, above 120; smaller vascular
bundles of the peripheral part completely sunk within the chlorenchymatous tissue and the major
one half within the chlorenchymatous tissue and the other half on the ground tissue, towards the
center the number of vascular bundles gradually decreases in number; vascular bundles of
peripheral region with the sclerenchymatous girder upto the epidermis at peripheral end, not at
central end; the smaller vascular bundles devoid of the girder but surrounded by single or double
cell layers of sclerenchymatous tissue; peripheral girders baculiform to securiform; central girders
crescentiform; vascular bundles at the ground tissue having sclerenchyma on both sides; vascular
bundles, away from periphery, having sclerenchyma on both sides and arranged in many cell-
layered conditions.

Leaf: The leaf V-shaped in cross section and dorsiventrally distinct; hinge portion of the
lamina widely V-shaped; specimen examined 1.5-2 cm long, wider at the V-shaped leaf portion.
Epidermal papillate extensions absent both in adaxial and abaxial layers; adaxial cells always
larger than the abaxial cells; keel protruding, apex acute; adaxial cells much smaller at the region
of the attachment of sclerenchymatous girder, cells elliptical to barrel-shaped; in the hinge region
cells single-layered, bulliform, 11-12 in number, vertically elongated, larger than the other
epidermis cells; adaxial epidermis thickly cuticularized than the abaxial one. Sclerenchymatous
tissues: present on both sides of vascular bundles and forming girders in case of major vascular
bundles and only 1-3 cell-layered in minor ones; sclerenchymatous girders somewhat Y-shaped,
cap like in hinge or keel regions vascular bundle and securiform and crescentiform in case of
other major vascular bundles. Mesophyll tissue: made of chlorenchyma cells, well developed
around the air cavity; cells ovoid to circular, smaller in comparisons to adaxial epidermal cells;
slightly larger than abaxial epidermal cells. Air-cavities: arranged alternately with the major
vascular bundle but below the minor vascular bundles overtopping; air chambers nearly square to
rectangular in outline; translucent cells within air cavity large, rectangular to penta- or hexa-
gonal. Vascular bundles: arranged in a single row, 11-13 in number in each half; major bundles 6-
7, minor bundles 6-7, arranged alternately, oblong in shape except at the marginal one; metaxylem 2-3, conspicuously present. Sclerenchymatous tissues surrounding the vascular bundle;
sclerenchymatous girder in major vascular bundles; in minor vascular bundle sheath cells outer
parenchymatous, mostly interrupted adaxially and abaxially by sclerenchyma. Bulliform cells
present only in the adaxial epidermal layer, in a layer in hinge portion and singly in other region.
Fig. 58. Habit and inflorescence of *Carex cruciata* var. *argocarpus*

A. Habit; B. Inflorescence (diagrammatic); C. Inflorescence with arrangement flowers (in part).

- Male flower.  
- Female flower.  
- Sterile flower

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*Fig. 58. Habit and inflorescence of *Carex cruciata* var. *argocarpus*

A. Habit; B. Inflorescence (diagrammatic); C. Inflorescence with arrangement flowers (in part).

- Male flower.  
- Female flower.  
- Sterile flower
Plate XXIV. Photographs of habit and infructescence of *Carex cruciata* var. *argocarpus*


Fig. 59. Morphology of glumes, utricle and nut of *Carex cruciata* var. *argocarpus*

A. 1st female glume; B. 2nd female glume; C. 3rd female glume; D,E. Utricles; F. Nut; G. T.S. of nut; H.I. Male glumes.
Plate XXV. Scanning electron microphotographs of utricle and nut of *Carex cruciata* var. *urgocarpus*

6. Top of nut (sbs= silica bodies).
Fig. 60. Anatomical features of culm of Carex cruciata var. argocarpus

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 61. Anatomical features of leaf of *Carex cruciata* var. *argocarpus*

A. T. S. of lamina (diagrammatic); B. Laminar groove (cellular); C. Laminar lateral portion (cellular); D. Laminar edge (cellular).
Plate XXVI. Microphotographs of culm and leaf of *Carex cruciata* var. *argocarpus*

1. T. S. of culm; 2. A portion of culm (magnified); 3. T. S. of lamina; 4. Laminar groove; 5. Laminar lateral portion; 6. Laminar edge. Scale bar-1, 3 (300 μm); 2-6 (200 μm).

**Description**

(Figs. 62-65; Pls. XXVII-XXIX)

**Morphology**

**Vegetative morphology:** Perennial herb; 50 to 120 cm long; caespitose, phyllopodic; group of 3-5 modules per genet or plant; loosely tufted. Roots light brown to dark brown, based upon age of roots; roots developed from the junction of the modules with older stolons, sometimes at the attachment site of stolon and soil, sometimes roots also arising from above ground part of aerial stems(culm); underground and ground level stems horizontal, stoloniferous; upto 30 cm long, stout, hard, clothed with the remaining of older sheath, loosely covered, slightly spongy; covering sheath pale brown, persistent till next 2-3 years/seasons, not breaking down, not fibrillose, even not breaking down into fibrous reticulation in the upper part of stem(culm). Leaves in basal clusters, in tufts of 5-11; blades existing for single season; sheath generally persistent in older part of the stem; 4-5 basal leaves bladeless in immature plantlets, reddish brown, persisting, ensheathing, not breaking down into any kinds of fibers, along with the leaf-sheath form a conspicuous build up at the base of plant; leaf-blades 35 to 80 cm long and 4 to 7 mm wide, straight, linear, W-folded in cross section, greatly exceeding or overtopping the inflorescence top, with single midvein and two laterals on each side, scabrous along margins.

**Reproductive morphology:** Plant monoecious. Flowering stem(culm) 30 to 70 cm long, narrowly cylindric; culm much shorter than both foliage leaves and lower 2-3 bracts; leaves on the upper half of the culm; flowering nodes 5-9 per module; partial panicles 3-11, single or binate, oblong-lanceolate to sub-pyramidal; lower one on long exerted peduncle; rachis hispidulous (particularly the secondary branches and next level ramification); bracts leafy, closely associated with the base of the panicle; lower 2-3 alike to foliage leaf, 30 to 55 cm long and the lowest one longest, 4 to 6 mm wide, margins scabrous; lower bract-sheaths distinct, enclosing the culm, 12 to 15 mm long, covering the lower part of the peduncles; in the upper nodes bracts gradually decreasing in length and breadth, ultimately becoming filiform; all bracts persistent.
Inflorescence of massive panicle, 20 to 40 cm long, partial panicle inserted singly per node; spikes numerous; branchlets and spikes evenly spaced; cladophyll present; individual spike short; longest one 10 to 11 mm long, predominantly female with upper 4-5 male flowers and all androgynous; female flowers 7-9 on longest spike; female portion 5 to 9 mm long and male portion 3 to 4 mm long; individual spike ovate to linear-oblong; basal 1-2 flowers sometimes sterile; female flowers spreading at maturity; male flowers in close set. Pistillate portion distinct, 5 to 9 mm long, 5 to 12-flowered; female glumes much shorter than utricles, 2.5 to 2.7 mm long, ovate to lanceolate, slightly mucronate-apiculate, with bristles; veins 1-3, distinct; with some pale orange-colored streaks on both the sides of veins, ferruginous, glabrous except apex; stigmas 3. Staminate part inconspicuous, comparatively shorter, 2 to 4 mm long, 4-5-flowered; male glumes ovate to elliptic, 2.7 to 3.2 mm long, single mid-veined, apex acute, ferruginous; stamen 3. Utricles spreading at maturity, much swollen at maturity, slightly to shortly inflated, ovoid to oblong when immature, having a distinct constriction at base, 3 to 3.7 mm long, substipitate, 3-4-veined, prominent in fruiting panicles; lower part of utricle glabrous, scaberulous; margin towards apex slightly hispidulous; abruptly constricted into comparatively longer straight beak; beak 1.2 to 1.7 mm long, aperture oblique but not bidentate; fucous green at maturity with black and red dots on upper half. Nuts ellipsoid, trigonous, 2 to 2.5 mm long, triangular in cross section at middle, covering the basal 2/3rd of utricle, substipitate, dark-brown to blackish brown.

Anatomy

Culm: In transverse section culm obtusely triangular; corners rounded, epidermis slightly rounded; epidermal cells papillate; the specimen studied about 0.5cm long. Translucent ground tissue towards the center, spongy and without air cavities in ground tissue portion; cells of ground tissue oval to polygonal and larger in size. Air-cavities: present in the peripheral region, alternate to the major vascular bundles, oval to rectangular in outline; the cells within chambers nearly quadrangular to rectangular, well surrounded with chlorenchyma cells. Assimilatory tissue: chlorenchymatous, present at the periphery region, 12-14 cell-layered thick; cells variously shaped, elliptical to polygonal, continuity of the layer interrupted by the presence of sclerenchymatous girders and air cavities. Vascular bundles: scattered throughout the ground tissue and with chlorenchymatous tissue in the peripheral region; vascular bundles 100 to 120.
more or less in 3-5 concentric rings, maximum numbers of vascular bundle oval in shape but some minor vascular bundles rounded in shape, 2 conspicuous metaxylems present in each vascular bundle or sometimes more than 2. Sclerenchymatous tissue: on both sides of both major and minor vascular bundles; peripheral major vascular bundles region with the sclerenchymatous girders; girders connected to the epidermal cell of the culm, only at the peripheral girders: girders towards centre absent or inconspicuous; vascular bundles of ground tissue devoid of girders. just surrounded by sclerenchyma tissues; sclerenchymatous tissues at the peripheral region in form of girders attached with the epidermis, present on both sides of vascular bundles; shape of the girder ranges from baculiform to deeply crescentiform in major vascular bundles and the cap in case of minor vascular bundles.

Leaf: Leaf V-shaped in cross section, dorsiventral, margins often flanged, broader at the keel portion and the median portion between keel and margins, slightly trapped towards the edge or margins; hinge portion V-shaped; keel protruded slightly at the abaxial side; apex slightly rounded; length of the studied specimen 1-2 cm. Epidermis: adaxial cells larger than abaxial epidermal cells; epidermal cells without any papillate extension, in both cases the epidermal cells smaller at the point of attachment of sclerenchymatous girder; cells of adaxial portion oblong-ovate but barrel-shaped in abaxial portion; cuticular layer thick in adaxial epidermis and thin in abaxial epidermis. Mesophyll tissue: chlorenchyma cells present as continuous layer but interrupted by the presence of vascular bundles and air cavities; tissue well developed around the air cavities and smaller vascular bundles. Sclerenchyma tissue: associated with all the vascular bundles, present on both sides of vascular bundles; sclerenchyma girder formed in both sides of major vascular bundles; girders ascending crescentiform in abaxial portion and cap in adaxial portion, in case of hinge/keel vascular bundle securiform to V-shaped; in adaxial part crescentiform in major vascular bundles and 1 to 2 cell-layered in tip portion of vascular bundles. Vascular bundle: arranged in single row, 9-12 in one half of the lamina, equidistant from both epidermal layers, oval, with 2-3 conspicuous metaxylems; sclerenchyma cells on both sides of the vascular bundles; major and minor bundles arranged alternately; minor /smaller vascular bundles near to adaxial epidermis; sclerenchyma girders of middle major vascular bundle extended upto adaxial and abaxial epidermis; other major vascular bundles having only adaxial girders; minors vascular bundles surrounded by 1-2 layers of sclerenchyma cells; bundle sheath cells 2-layered.
outer parenchymatous and inner sclerenchymatous; mostly interrupted by sclerenchyma both on abaxial and adaxial side. Air cavities: arranged alternately with the vascular bundles, rectangular to oblong in outline; cells rectangular to nearly tetrangular in shape. Bulliform cells present only in adaxial side, 10 -11, single-layered in hinge region, at the point of attachment of sclerenchyma girder arranged singly or in layer.
Fig. 62. Habit and inflorescence of Carex cruciata var. nagporensis

A. Habit(lower portion); A1. Habit(upper portion of culm); B. Inflorescence( one half of a peduncle (diagrammatic).

Male flower, — Female flower, — Sterile flower
Plate XXVII. Photographs of habit and inflorescence of *Carex cruciata* var. *nagporensis*

A. Habit; B. Inflorescence(magnified).
Plate XXVIII. Photographs of habit and inflorescence of *Carex cruciata* var. *argocarpus* (1-5 and 6b) and *C. cruciata* var. *nagporensis* (6a)

Fig. 63. Morphology of male and female glumes, female flower, utricle and nut of *Carex cruciata* var. *nagporensis*

A., B and C., Female glumes; D. Female flower with style and stigma; E. Utricle; F. Utricle splitted open; G. Nut; H. T.S. of nut; I and J. Male glumes.
Fig. 64. Anatomical features of culm of Carex cruciata var. nagporensis

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 65. Anatomical features of leaf of *Carex cruciata* var. *nagporensis*

A. T. S. of lamina (diagrammatic); B. Laminar groove (cellular); C. Laminar lateral portion (cellular); D. Laminar edge (cellular).
Plate XXIX. Microphotographs culm and leaf of *Carex cruciata* var. *nagporensis*
1. T. S. of culm; 2. A portion of culm(magnified); 3. T. S. of lamina(middle region); 4. Laminar groove; 5. Laminar lateral portion; 6. Laminar edge. Scale bar-1 and 3(300µm); 2-4(200µm); 5-6(100µm).


Description (Figs. 66-70; Pls. XXX-XXXI)

Morphology

Vegetative morphology: Perennial herb, 50 to 90 cm long, highly caespitose, aphyllopodic; generally having 15-20 modules per genet or plant; rarely often with 50-70 modules per plant, densely tufted. Roots dark-brown to blackish brown, highly tomentose. Underground and ground level stems horizontal, hard, stout, stoloniferous, comparatively shorter, 10 to 15 cm long; older stolon covered or clothed with leaf-sheath at the apex; sheath loosely covered, reddish brown, not persistent, breaking down into fibrillose structure, more prominent in 2-3 years old leaf-sheath; roots not emerging from the nodes of the aerial part of stem. Leaves in sub-basal cluster of 5-7 rarely upto 10; blades existing for a single season but sheath of leaf persistent; basal 3 to 4 or rarely 5 leaves bladeless, reddish brown to purplish, persistent in immature plantlets, finally becoming fibrillose at maturity, building up/ forming as the fibrous sheath of foliage leaves; leaf-blades sub-basal and on the basal half of the culm; blades 40 to 55 cm long, comparatively narrower, 2.5 to 4 mm wide, straight, linear, V-shaped in cross section, greatly exceeding the inflorescence top, with 3-4 faint veins on each side of the middle one; margins highly scabrous.

Reproductive morphology: Plant monoecious. Flowering stem/culm 35 to 55 cm long, much shorter than foliage and first 2-3 bracts; flowering nodes 4-9 per module; bracts leafy (atleast basal 2-3), closely associated with the base of culm; lower 2-3 alike leaf-blades, greatly exceeding the inflorescence top; lowest one longest, 35 to 50 cm long and 3 to 3.5 mm wide; surface as like as foliage leaves; bract-sheath distinct, 2.5 to 3.5 cm long in lowest one, covering lower part of peduncle; bracts gradually decreasing in length in upper nodes and breadth of blade as well as length of sheath; bracts finally become filiform, persistent at maturity. Inflorescence massive, dense, paniculate, 25 to 40 cm long; peduncles 1-2 per node, rarely 3; lowest peduncle
longest, 8 to 10 cm long, many-spiked; partial panicle cylindrical; axis of partial panicle filiform, flexuous; secondary branches scarcely developed; spikes generally appeared as cluster of 3-5; bracteoles with conspicuous filiform tips; individual spike ovate to elliptic, shorter, longest one 6 to 7 mm long; all androgy nous, predominantly male on top, 15-20-flowered; basal 1-2 glumes sometimes sterile. Pistillate portion distinct, 2 to 3 mm long, 2-4-flowered; female glumes longer than or equal to utricle, 2.2 to 2.75 mm long, ovate-elliptic, lowest one aristate or cuspidate; other glumes mucronate or epiculate, apex bristled; lower half of glume reddish brown with straw-colored elongated streaks on both the surfaces, generally single-veined, glabrous; stigma 3. Staminate part conspicuous, comparatively longer, 4 to 6 mm long, 12-15(18)-flowered; male glumes elliptic to lanceolate, single-veined, with straw-colored elongated streaks, sometimes with straw-colored patches, apex apiculate, glabrous; stamens 3. Utricles smaller, 2.2 to 2.7 mm long, 4 to 4.5 mm including stigmas, equal to the length of glume, spreading at maturity, 5 to 6-veined, indistinct, distinctly shouldered into short 0.5 to 1.0 mm long beak; beak straight, sometimes reflexed, distinctly bidentate, hispidulous, chest nut-colored. Nuts ellipsoid-trigonous, triangular in cross section at middle part, 2 to 2.2 mm long, fitting well the utricles; stipitate, light brown.

Anatomy

Culm: culm triangular in cross section; one angle sub-acute and other two angles rounded; studied specimen about 0.5 cm long; ground tissue translucent towards the center, spongy in nature and devoid of air cavity. Air-cavities: present in the peripheral region, rectangular or oblong in outline, well surrounded by the chlorenchyma cells, translucent aerenchyma cells present within the cavity. Assimilatory tissue: as chlorenchyma cell layers present at the peripheral region of the culm, interrupted by the presence of air cavities and vascular bundles. Vascular bundles: 50-55 in number, in two concentric rings; peripheral vascular bundles in a single ring, arranged alternately as major and minor bundles; other vascular bundles scattered in ground tissue; minor vascular bundles of peripheral region totally embedded in chlorenchyma; major bundles partially embedded in chlorenchyma and partially in ground tissue. Sclerenchyma cells: present on both the sides of vascular bundles; peripheral vascular bundles with adaxial sclerenchymatous girder attached with the epidermal layer; vascular bundles oval in shape and with large conspicuous 2 to 3 metaxylems. Sclerenchyma tissue: forming a girder at
peripheral region; shape of the peripheral girder Y-shaped or baculiform; shape of the central girder crescentiform; vascular bundles of ground tissue having cap-shaped sclerenchymatous layers on both the sides and joined each other by a single layer of sclerenchyma itself.

Leaf: Leaf blades widely W-shaped in cross section, dorsiventral; keel protruding and rounded; lamina thick towards marginal part; apex of margins gradually tapering and acute; studied specimens 0.4 - 0.5 cm long. Epidermis: adaxial cells several times larger than the abaxial epidermal cells; epidermal cells over the sclerenchymatous girder quite smaller in both the cases; cells of the hinge portion of adaxial layer larger, oblong and two-layered; upper layer 8-celled and lower layer 12-celled; cuticle layer thick on adaxial layer but thin on abaxial layer. Sclerenchyma tissue: present on both the sides of vascular bundles; sclerenchyma as adaxial girder in hinge/keel vascular bundle crescentiform and abaxial girder as cap of 1-2 layers; sclerenchyma girder in other vascular bundles baculiform on adaxial face and crescentiform on abaxial face; 1-2 layers of sclerenchyma cells surrounding the minor vascular bundles of the marginal portion. Mesophyll tissue: chlorenchymatous, well developed, interrupted by the presence of air cavities. Air-cavities: rectangular to oblong in outline with round to oval-shaped aerenchyma cells within; air-cavities surrounded by chlorenchyma tissue. Vascular bundles: 8-9 in each half of the lamina, arranged in single row; major and minor vascular bundles arranged alternately, equidistant from each other as well as from adaxial and abaxial epidermis; sclerenchyma cells: present on both the poles of vascular bundles; vascular bundles oval in shape with 2-6 large metaxylems arranged in triangular fashion as 2 single side by side and other above two in one group; bundle sheath 2 cell-layered, outer parenchymatous and inner sclerenchymatous, interrupted by sclerenchyma cells. Bulliform cells present in the adaxial side.
Fig. 66. Habit and inflorescence of *Carex burttii*

A. Habit; B. Inflorescence (in part).
Plate XXX. Photographs of habit and inflorescence of *Carex burttii*
1. Habit; 2. Inflorescence (magnified in part).
Fig. 67. Morphology of glumes of *Carex burttii*

A. Sterile glume; B. 1st female glume; C. 2nd female glume; D. 3rd female glume; E. 1st sterile female glume; F. 2nd sterile female glume; G,H,I and J Fertile female glumes from middle portion of spike.
Fig. 68. Morphology of female flower, glumes, utricle and nut of *Carex burttii*

A. Utricle with style and stigma; B. Utricle with female glume; C. Utricle splitted open;
D. Nut; E. T.S. of nut; F,G. Male glumes.
Fig. 69. Anatomical features of culm of *Carex burttii*

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 70. Anatomical features of leaf of *Carex burttii*

A. T. S. of lamina (diagrammatic); B. Laminar groove (cellular); C. Laminar lateral portion (cellular); D. Laminar edge (cellular).
Plate XXXI. Microphotographs of culm and leaf of *Carex burttii*

1. T. S. of culm; 2. One corner of culm (magnified); 3. T. S. of lamina; 4. Laminar groove; 5. Laminar lateral portion; 6. Laminar edge. Scale bar-1 and 3 (300 µm); 2, 4 and 6 (200 µm); 5 (80 µm).

Description (Figs. 71-75; Pis. XXXII-XXXIII)

Morphology

Vegetative morphology: Perennial herb, mostly found in low altitudinal grazing zone, usually 30 to 65cm high, rarely to 75cm, caespitose, phyllopodic; modules up to 17 per plant, very densely tufted. Roots light brown to creamish white, not tomentose. Underground stem rhizomatous; rhizomes very stout, hard, deep brown, obliquely horizontal, 1.5 to 2.5 cm long, covered with deep brown scales; upright stems clothed with bases of leaf-sheath, persisting as long fibers, pale when dried, striped with distinct veins; gradation of colours of sheath present from base to apex as dark-brown at base and gradually become light brown towards apex; reticulation absent in sheath. Leaves very distinctive, comparatively shorter but much more wider, in basal tufts of 7-13; blades mostly grazed by domestic animals, existing for a single season; sheaths persisting for several seasons; basal 1-3 bladeless sheaths of leaf persist even in mature plant; bladeless leaf pale brown, form a conspicuous build up at the base; leaf-blades usually shorter than the culm, at maturity hardly reaching the top of the inflorescence, rarely exceeding the top of inflorescence, 35 to 45 cm long and 7.5 to 13.5 mm wide, thin textured, pale green to light green, generally V- shaped in cross section, with single midvein and 4 secondaries on each side; one pair of secondary as prominent as midvein, surface glabrous, margins coriaceous.

Reproductive morphology: Plant monoecious. Culm 30 to 45 cm, rarely upto 50 cm long. Flowering nodes generally 2-3 per module, rarely reaching upto 6; bracts all greatly exceeding the inflorescence top; lowest one 25 to 35 cm long and 5.5 to 9 mm wide; upper bracts gradually decreasing in length and wideness; bract-sheath distinct, gradually decreasing in length; lowest sheath 8.5 to 9.5 cm long, partially covering the culm. Inflorescence dense paniculate, 20 to 40 cm long; lower partial panicle single, broadly triangular in outline, widely spaced at maturity, though very dense in immature condition, creammish white in young and at maturity:
peduncle generally single per node; lowest one longest, excluding the ensheathing part. 7 to 12 
cm long; lower peduncles distant, 8 to 12 cm long; glabrous except the secondary branches of 
panicle; bracteoles with scabrid point, 1.5 to 3 mm long; spikes 20-75 per node; individual spike 
 sessile, very short, 5 to 13 mm long, variable in length from one module to another; spike 12-41-
flowered, all spikes androgynous, predominantly male, with basal 4-6 female flowers; sexuality 
not distinguishable in immature condition; basal 1-2 glumes distantly placed, ovoid to elliptic, 
cream coloured; female portion (utricles) spreading at maturity; male portion always in close set. 
Pistillate portion basal, inconspicuous when immature, distinct at maturity, 1.5 to 3.5 mm long, 4-
6-flowered; female glumes as long as utricles when immature, much shorter at maturity. 2.5 to 
4 mm long including the projection; body of female glume gradually increasing in length from 
base to apex and up to certain distant; projection gradually decreases in length towards apex: 
sometimes all female glumes projected, ovate, scabrid and awned; largest awn 2.5 mm long; 
cream-coloured; 1-3-veined with several inconspicuous parallely arranged laterals; midvein 
scabrid in basal 1-2 glumes; style linear, short; stigma 3, short, curved, surface muricate. 
Staminate part distinct, larger than the female portion, compact, 3.5 to 9 mm long, 10-35-
flowered, cream-coloured, conical in shape; male glumes ovate to lanceolate, 4 to 4.7 mm long. 
shortly excurrent, mucronate, with scabrid tip, 1-3-veined, severely ribbed on each side of 
midvein; stamens 3, equal in length; filaments comparatively shorter when young, 1 to 1.5 mm 
long, much elongated at maturity (anthesis); anthers oblong-linear, crests appendiculate, not 
projected, 2 to 2.5 mm long. Utricles spreading at maturity, acutely trigonous, globose. rather 
large, 3.5 to 4.5 mm long, 20-25-veined, fuscous green, not curved, abruptly constricted into 
beak, faces narrowly rhomboid, glabrous; beak 0.7 to 1.5 mm long; apex hyaline, aperture 
slightly oblique, very shortly bifid, not notched. Nuts ovoid to ellipsoid, acutely trigonous, not 
stipitate, closely fitting in utricles, 2.5 to 3.7 mm long.

Anatomy

Culm: Culm obtuse-triangular in cross section; angles rounded with slightly concave 
sides; specimen examined 0.5-0.7 cm long. Central ground tissue translucent and spongy, devoid 
of air cavities. Air-cavities: more than 50 in the peripheral region within chlorenchyma tissue, 
rrounded to oblong with aerenchyma cells. Assimilatory tissue: as chlorenchyma cells much
thicker on outer face of air cavity than on other face. Vascular bundles: more than 70, 45-49 in peripheral row, others scattered and embedded in ground tissue, both major and minor vascular bundles arranged alternately at peripheral region, many of them elliptical in outline excluding sclerenchyma, with 2-10 metaxylems. Sclerenchyma tissue: present in most of the peripheral part of major and minor vascular bundles, baculiform in peripheral strands as girders and thick crescentiform in central bundles as caps; inner vascular bundles with crescentiform cap at both the ends.

Leaf: Leaf blade inversely W-shaped in cross section; margins often flanged; keel protruding and sharply acute; each half of lamina more or less of same thickness, slightly tapered to blunt pointed margins; pecimen examined 1-1.3 cm long. Epidermis: adaxial cells slightly larger than abaxial cells except at the leaf margins where cells of equal size; hinge region made up of 15-17 cells; cells vertically elongated, pallisade like and bulged, single-layered and bulliform; both adaxial and abaxial cells over sclerenchymatous strands quite smaller; cuticle layer more or less of same thickness at both the faces. Sclerenchyma tissue: in median vascular bundle present as horizontal adaxial strand/ girder and abaxial cap as crescentiform; vascular bundle of keel portion having crescentiform, abaxial V-shaped to securiform girder, extending upto epidermal layer; minor vascular bundles with thin layer of sclerenchyma and a patch of sclerenchyma cells at the adaxial side of the top portion and pulviniform in shape. Mesophyll tissue: chlorenchymatous, well developed around air-cavity, above and below the minor vascular bundles. Air-cavities: large, conspicuous and long-rectangular in outline, with oblong to oval aerenchyma cells. Vascular bundles: 16 in one half of lamina and 15 in other half, 4 to 5 larger major and other minor, equidistant from both the epidermal layers, oval in shape, with 2 to 4 large conspicuous metaxylem arranged in triangular fashion; bundle sheath 2 cell-layered, outer parenchymatous and inner sclerenchymatous, interrupted by sclerenchymatous cells at both abaxial and adaxial side in case of major vascular bundle, incomplete circle in case of minor vascular bundles of the tip portion. Bulliform cells on upper epidermis only.
Fig. 71. Habit and inflorescence of *Carex stramentitia*

A. Habit; B. Inflorescence (diagrammatic in part); C. Arrangement of flowers on spike.

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- Male flower
- Female flower
- Sterile flower
Plate XXXII. Photographs of habit and inflorescence of *Carex stramentitia*

1. Habitat and habit; 2. Inflorescence (magnified).
Fig. 72. Morphology of female glumes and utricle of *Carex stramentitia*

A. 1st fertile female glume; B. 2nd fertile female glume; C. 3rd fertile female glume;
D. 4th female glume; E. 5th female glume; F. G., Immature utricle.
Fig. 73. Morphology of female flower, utricle, nut and stamens of *Carex stramentitia*

A. Female flower with style and stigma; B. Utricle splitted open; C. Nut; D. T.S. of nut; E and F., Male glumes; G. Stamens.
Fig. 74. Anatomical features of culm of *Carex stramentitia*
A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 75. Anatomical features of leaf of *Carex stramentita*

A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate XXXIII. Microphotographs of stem and leaves of *Carex stramentitia*

1. T. S. of culm; 2. A portion of culm (magnified); 3. T. S. lamina(middle portion); 4. Laminar groove; 5. Laminar lateral portion. Scale bar- 1, 3 and 5(300\(\mu\)m); 2 and 4(200\(\mu\)m).

Description (Figs.76-80; Pls. XXXIV-XXXV)

Morphology

Vegetative morphology: Perennial herb, 60 to 90 cm or rarely to 120 cm long, phyllopodic, caespitose; modules 5-7 per genet/plant, loosely tufted. Roots light brown. Underground or ground level stems generally bulbous, sometimes creeping, flashy, comparatively short, rarely creeping, without development of stolons at all. Leaves in basal tufts of 5-11: basal 3-4 leaves bladeless, reddish purplish, persisting along with sheath of the bladed foliages: bases of leaf-sheath reddish purple, persistent, not becoming fibrillose or not breaking down to reticulate fibers; margins of leaf-sheath along with bladeless leaf become fibrillose; leaves 1-3 on culm; leaf-sheaths form a conspicuous build up at the base of plant/culm; blades 50 to 70 cm long and 4 to 12 mm wide, generally exceeding the inflorescence top, 15-25 cm, linear, straight. W-shaped in cross section, single mid-veined and with 2-3 laterals on each side of mid vein.

Reproductive morphology: Plant monoecious. Flowering stems 30 to 115 cm long, much shorter than the leaf-blades and lower 2-3 of the bracts. Flowering nodes 3-6 per module; lower 3-4 bracts leafy, overtopping the inflorescence; lowest one longest, 30 to 45 cm long and 4 to 6 mm wide, surface as like as foliage; bract-sheath distinct at least for lower 3-4 bracts. 3 to 4.5 cm long, covering the base of peduncle; bract-sheath gradually decreasing in length and wideness in upper nodes and ultimately become filiform; bracteoles inconspicuous and usually under 3 mm long. Inflorescence massive, paniculate, 20 to 85 cm long; peduncles 1-2 per node, 3-4 cm long; partial panicles usually in equal pairs, open, rigid, triangular in outline; axis hispid, often very dense; branches comparatively slender; branchlets and spike evenly spaced; individual spike sessile, decreasing in length markedly upwards and variable in size within inflorescence; longest
one 14 to 15 mm long, 17 to 25-flowered, prominently female, all androgy nous, ovate to linear-oblong, flowers loosely spaced, spreading at maturity. Pistillate portion distinct, 8 to 13 mm long; 9 to 15-flowered; female glumes shorter than the utricles or as long as the body of the utricles, 2.5 to 3.2 mm long, ovate, sometimes elliptic-lanceolate, acute or occasionally minutely mucronate, glabrous or rarely minutely hispid; distinctly single-veined, pale brown to rusty brown or occasionally straw-coloured; style 1 to 1.5 mm long, base slightly dilated or bulbous; stigma 3, curved. Staminate portion indistinct, 2.5 to 5 mm long, 4 to 9-flowered; male glumes elliptic-lanceolate, 2.5 to 3.2 mm long, always single-veined, apex acute or slightly apiculate, straw-coloured, with irregularly arranged elongated spots of dark brown colour; stamens 3. Utricles spreading to deflexed at maturity, lax, evenly spaced, curved, narrowly ellipsoid when immature, trigonous, at maturity ovate, 2.5 to 3 mm long, slightly stipitate, 5-6-veined, sometimes nearly 20-veined, gradually narrowed into typical, angled, deflexed beak; beak 0.7 to 1.3 mm long, glabrous, olive-green, apex hyaline, aperture oblique, never notched or never bidentate; beak slightly hipidulous/serrate; upper half of utricle with light brown to reddish brown dots. Nuts ellipsoid-trigonous to ovoid-trigonous, subsessile, 1.5 to 1.7 mm long, triangular in cross section at middle, fitting closely with utricle, dark-brown to black.

Anatomy

Culm: Culm obtusely triangular, with rounded angles, having distinct epidermal papillae and silica bodies, margin slightly concave; studied specimens about 1.5 cm long. Translucent ground tissue: towards the center, spongy and devoid of air cavity within ground tissue. Air-cavities: present only at the peripheral region, arranged alternate to the vascular bundles and girder of sclerenchyma; aerenchyma cells present within air-cavity, rectangular to transversely oblong-shaped. Assimilatory tissue: as chlorenchyma layer present at the peripheral region of the culm and interrupted by the presence of sclerenchyma girders, vascular bundles and air-cavities. Vascular bundles: 45-50 in the peripheral region and forming a row; other vascular bundles scattered in the ground tissue and few in number towards the center; vascular bundles mostly oval, with 2-3 conspicuous large metaxylems; sclerenchymatous girder present in all the vascular bundles of the peripheral region extending upto the epidermal layer; sclerenchyma tissue present mostly with the vascular bundles forming the girder, also as indendependent patches in peripheral
region; girder triangular, baculiform in case of peripheral major vascular bundles; all the inner minor vascular bundles surrounded by sclerenchyma either in one or in many-celled layers.

Leaf: Leaf blades flanged with W-shaped in cross section; keel protruding, rounded; lamina thickest at the keel portion, intermediate in between keel and margins, tapered gradually towards the margins; specimen examined 1-1.5 cm long. Epidermis: abaxial layer hugely adorned with papillate extension below the hinge region; adaxial epidermis with few papillae near and/or above the hinge region and cells much larger than abaxial cells; the epidermal cells over the sclerenchyma girder much smaller in both the cases, oblong to barrel-shaped; cuticular layer thick on adaxial layer and less thick on abaxial layer; hinge with 12-15 large, single-layered bulliform cells; sometimes presence of a second incomplete layer of hinge cells. Sclerenchyma: mainly associated with the vascular bundles; sclerenchyma girder in the hinge portion only at the abaxial side and attached with epidermal layer, sacuriform; the adaxial side cap-shaped; in keel or median portion the sclerenchymatous girder present on both sides of the vascular bundles and extending up to the epidermal layers; the adaxial girders sub-T-shaped but the abaxial girder turbiform; minor vascular bundles with single layer of surrounding sclerenchyma. Mesophyll tissue: made of chlorenchyma cells, well developed and surrounding the air cavities. Vascular bundles: 16-17 in each half of the leaf blade; major bundles 9 and remaining minor, alternately arranged and equidistant from adaxial and abaxial epidermal layers, each one oval in shape and with 2 large metaxylems; larger vascular bundles with sclerenchymatous girder attached with the epidermal layers. Bulliform cells: 10-11, arranged in a single layer in hinge region and others in adaxial epidermis only. Vascular bundle sheath double cell-layered; outer parenchymatous and inner sclerenchymatous; major vascular bundles sheath layer interrupted by the sclerenchyma cells while in minor bundles the bundle sheath forming complete layer and without any interruption.
Fig. 76. Habit and inflorescence of Carex filicina

A. Habit; B. Floral arrangement on spike (diagrammatic in part)

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Plate XXXIV. Photographs of habit and inflorescence of *Carex filicina*

Fig. 77. Morphology of female glumes, utricle and nut of *Carex filicina*

A, B., Female glumes; C, D., Immature utricles; E, F., Utricle splitted open; G. Immature nut with persistent style and stigma; H. Mature nut; I. T.S. of nut.
Fig. 78. Morphology of utricle, nut, male glumes and stamens of *Carex filicina*

A. Mature utricle with persistent stigma; B, C. Upper potion of nut with stigmatic projections; D, E. Male glumes; F. Stamens.
Fig. 79. Anatomical features of culm of *Carex filicina*

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 80. Anatomical features leaf of Carex filicina

A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate XXXV. Microphotographs of anatomy of culm and leaf of *Carex filicina*

1. T. S. of culm; 2. A portion of culm (magnified); 3. A portion of culm further magnified showing papillate epidermal cells; 4. T. S. of lamina; 5. Laminar groove; 6. Laminar lateral portion and edge. Scale bar-1, 4 and 6(300\(\mu\)m); 2(200\(\mu\)m); 3 and 5(80\(\mu\)m).

Description (Figs. 81-84; Pls. XXXVI-XXXVII)

Morphology

Vegetative morphology: Perennial herb, 45 to 60 cm long, caespitose, phyllopod. upto 50 modules per plant/genet, loosely to densely tufted with more modules. Roots light dark-brown. Underground stem (rhizome) short, stout, hard, often slightly stoloniferous and horizontal; 5 to 7mm long; above ground stem clothed with remains of older leaf-sheaths; sheaths loosely covered, pale brown on drying or reddish brown, stripped with distinct dark veins, not breaking down to any fribillose structure; margins or mouth of older leaf-sheath breaking down into inconspicuous reticulate fibres. Leaves sub-basal, 5-7 in cluster; 2-3 leaves on basal part of the culm; basal bladeless sheaths several, dark-brown coloured, persisting, very loosely arranged, never breaking down into fibres; bladeless sheath and sheath of foliage together constitute a conspicuous build up at the base of plant; blades 45 to 50 cm long, comparatively narrow, 5 to 7 mm wide, greatly exceeding or overtopping the inflorescence top, ‘W’- shaped in cross section; single midveined; others inconspicuous parallel, surface and margins scaberulous.

Reproductive morphology: Plant monoecious; culm 4.5 to 17.5 cm long, much shorter than the blades as well as lower bracts, particularly lower 3-4 bracts; leaves 2-3 at base. Flowering nodes 4-6 per module; lower 3-4 bracts leafy, much overtopping the inflorescence top; lower bract longest, 35 to 46 cm long and 2 to 5 mm wide; bract-sheath distinct; lowest one to 3.5 cm long, compactly covering the lower part of peduncle, partially covering the culm in the upper nodes; bracts length and length of sheath and breadth of bracts gradually decreasing in size; bracteoles present, scabrid. Inflorescence elongated, cylindric, paniculate, nearly continuous, scarcely interrupted at base with numerous solitary spikes, evenly spaced, 8.5 to 27.5 cm long; partial panicles cylindric, less pyramidal, generally inserted in pairs; lower one sometimes solitary, 6-25 rarely upto 30 spiked; in each pair one peduncle always longer than second one; lowest peduncle longest, to 4.5 cm long excluding the ensheathed portion; lowest node wider
from the second flowering node and to 9.5 cm wide; individual spike close together, evenly spaced, not clustered as in Carex condensata, finely brown, sessile, short as 6 to 10mm rarely upto 12mm, 14 to 20-flowered, ovate to elliptic in outline, predominantly female with terminal few as 2-3 male flowers; basal 1-2 glumes often sterile, all androgynous; female flowers spreading at maturity, male portion in close set. Pistillate portion distinct, comparatively longer. 5 to 7mm long; 5-15 rarely up to 17-flowered; female glumes sometimes bristled; bristle as long as utricle, ovate-lanceolate, 2 to 3.5 mm long, gradually increasing in length towards top; sterile female glumes shorter, basal one long bristled; bristle upto 3.5 mm long, single-veined; both midvein and bristle scabrid; female glumes of upper part acuminate-apiculate, single-veined with ribbed wings, finely brown; style shorter, 0.5 to 0.7 mm long, linear, base dilated or not; stigma 3, comparatively longer, 2.5 to 3.5 mm long, sometimes unequal in length, sometimes longer than the utricle, fimbriate. Staminate portion inconspicuous, much shorter, 2 to 3.5 mm, 2-3-flowered, light brown; male glumes ovate, 2.7 to 3.2mm long, acute to acuminate, single-veined; midvein not scabrid; stamens 3, equal in length; filaments comparatively longer at maturity, 2.5 to 3.5 mm long; anthers linear to linear oblong. Utricle ovoid-narrowly ellipsoid, trigonous, 3 to 3.5 mm long, 4-12-veined; veins strong; brown; gradually tapered into straight-slightly curved beak: beak 0.7 to 1.2 mm long; aperture deeply bidentate, hispidulous at margins of utricle and at the base of beak. Nuts ovoid-ellipsoid, trigonous, triangular in cross section, with rounded angles. not stipitate, closely fitting with utricle, 2.2 to 2.5 mm long, deep brown.

Anatomy

Leaf: Lamina V-shaped or slightly revolute to slightly flanged in outline, dorsiventral; keel prominent and protruding towards abaxial, forming a prominent ridge on abaxial and groove on adaxial side, acute, terminated by a conical silica body or papilla; lamina thickest in median portion of wing (between median vascular bundles and edge), sometimes marginal portion as much thick as median part, comparatively thin near the keel region; specimens examined 0.5 to 0.75 cm long. Epidermis: adaxial cells larger than abaxial cells, asymmetrical; cells at the point of attachment of sclerenchyma smaller on adaxial side, adaxial cells largest at hinge region; hinge consisting of 10-11 largest bulliform cells; abaxial epidermis devoid of bulliform cells and palisade cells; cells more or less uniform, barrel-shaped. Sclerenchyma tissue: generally
associated with vascular bundles; in hinge or keel region sclerenchyma form a girder at the abaxial epidermal layer; on adaxial side 2-3 cell-layered thick sclerenchyma form a cap like structure on and above the vascular bundles, but not extending up to the adaxial epidermis; vascular bundles of intermediate position between keel and margins connected also with massive sclerenchyma girders on both the adaxial and abaxial sides; 12-15 cell-layered thick, abaxial crescentiform, 5-7 cell-layered; minor vascular bundles surrounded by 2-3 cell-layered sclerenchyma tissue and totally devoid of girder in the margins just opposite to last vascular bundle; on the adaxial side, 2-3 cell-layered, single patch of sclerenchyma also present, not connected with the vascular bundle. Mesophyll: as chlorenchyma tissue, well developed, devoid of palisade parenchyma, uniformly extending from adaxial epidermis to abaxial epidermis, interrupted by aerenchyma and vascular bundles; cells more or less isodiametric, oval to rounded. Air cavities: with aerenchyma cells distributed between vascular bundles alternately, rectangular-oblong in outline, surrounded by chlorenchyma cells. Vascular bundles: all in abaxial half, in single row, 12-13 on each side of lamina; major and minor vascular bundles in alternating fashion, equidistant from the epidermal layer, oval in shape having 3-6 metaxylems placed in 2-3 directions, arranged in groups or singly having massive sclerenchyma on each side of vascular bundles, extending up to the epidermis in major vascular bundles, forming a girder and just surrounding in case of minor vascular bundles. Bundle sheath double cell-layered thick; the outer parenchymatous interrupted by sclerenchyma girder and the inner sclerenchymatous. Bulliform cells present only on adaxial epidermis, bulged, comparatively larger and longer, sometimes papillate.
Fig. 81. Habit and inflorescence of *Carex continua*

A. Habit (lower and upper part only); B. Inflorescence of single peduncle; C. Floral arrangement in a single spike.

- Male flower
- Female flower, `vf`
- Sterile flower

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Male flower, `Male flower`, Female flower, `Female flower`, Sterile flower, `Sterile flower`
Plate XXVI. Photographs of habit and inflorescence of *Carex continua*

Fig. 82. Morphology of glumes and utricle of *Carex continua*

A. and B. Sterile glumes; C. 1<sup>st</sup> fertile female glume; D. 2<sup>nd</sup> fertile female glume; E. 3<sup>rd</sup> fertile female glume; F. 4<sup>th</sup> fertile female glume; G. Immature utricle with style and stigma.
Fig. 83. Morphology of male glume, utricle and nut of Carex continua
A. Utricle; B. Utricle splitted open; C. Nut; D. T.S. of nut; E. and F. Male glumes.
Fig. 84. Anatomical features of leaf of Carex continua

A. T. S. of lamina (diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate XXXVII. Microphotographs of the anatomy of leaf of Carex continua

1. T. S. of lamina; 2. Laminar groove; 3. Laminar lateral part; 4. Laminar edge.

Scale bar-1 (300μm); 2-4 (50μm).

Description (Figs. 85-88; Pls. XXXVIII-XL)

Morphology

**Vegetative morphology:** Perennial herb; 45 to 110 cm high, caespitose, phyllopodic; commonly 3-7 or very often 12 modules per plant, loosely to densely tufted. Roots dark-brown at maturity, not tomentose, tomentose when immature. Underground stems or the rhizomes stout, hard, horizontally spreading, shortly stoloniferous; stolons 2 to 3.2 cm long, ribbed, dark-brown; above ground stems clothed at apex with remainings of old leaf-sheaths; leaf-sheaths loosely covered, onion-coloured to deep brown, not breaking down into any fibrillose structure; sometimes margins of the older existing leaf-bases and remaining sheath of previous years breaking down into distinct reticulate fibre like structures. Leaves generally sub-basal, 4-7, on lower part of the culm; leaf-blades existing for a single season; basal bladeless sheath usually present, 2-5, reddish brown to onion-coloured, loosely persisting, never breaking down into fibres, forming a conspicuous build up at the base; leaf-blades 90 to 100 cm long and 6 to 8 mm wide, slightly exceeding the inflorescence top, straight, W-shaped in cross section, with single midvein, without distinct parallel veins, margins scabrous.

**Reproductive morphology:** Plant monoecious; culm 25 to 45 cm long, rare often extending to 60cm, much shorter than the blades and the lower 2-4 bracts. Leaves 2-3, on basal half of culm; flowering nodes 5-9 per module; lower 3-5 bracts leafy, slightly overtopping to rarely much overtopping the inflorescence axis, 15 to 25 cm long; lowest bracts longest, 35 to 50 cm long excluding the sheath, compactly covering the lower part of peduncle, partially covering the acute triangular culm; in the upper nodes both the sheath and the blade of bracts decreasing in length and breadth; bracteoles with scabrid points. Inflorescence massive, dense, elongated large paniculate structure, 23 to 47 cm long, more or less pyramidal in shape in partial panicle to oblong panicle; distinctly peduncled, with densely congested spike; partial panicle less long
peduncled, generally inserted in pairs, sometimes three, or rarely one; numerous spiked; in each pair one peduncle much shorter; peduncle longer, lowest one longest, 4.5 to 7.5 cm long excluding the ensheathed portion; lowest flowering node widest, 9.5 to 17.5 cm widest usually from second flowering node; spikes sometimes in a group of 5-12; individual spike sessile, 5 to 12 mm long, 19-25-flowered, predominantly male and with basal 4-6 female flowers; clustered, ferruginous, sometimes with 1-3 basal glumes sterile; all androgynous; female flower spreading at maturity, but the male portion in close set. Pistillate portion distinct at maturity, otherwise not separable. 1.5 to 2.5 mm long, 4-6-flowered; female glumes as long as utricle, 2 to 2.5 mm long, with variable extension like aristate, mucronate, apiculate; arista up to 1.5 mm long; single mid-veined, with ribbed wings, orange-brown to glistening reddish brown at maturity; style long 1 to 1.5 mm long; stylar base dilated; stigma 3, curved, as long as utricle, 2 to 2.5 mm long, with fimbriate surface. Staminate portion distinct, comparatively longer, 3.5 to 4 mm long, 15-20-flowered, ferruginous; male glumes ovate-elliptic, 3 to 4.2 mm long; apiculate-acute, single mid-veined, midrib and tip not scabrid; stamens 3, equal in length; filaments comparatively longer, length of filaments twice as long as anthers; anthers linear to linear-oblong, crests apendiculate, without any projection. Utricles few, always below six, spreading at maturity; narrowly ovoid to ellipsoid, trigonous, 2.5 to 3.5 mm long, 5-7 faintly veined, as long as female glumes or slightly exceeding female glumes, olive-brown, gradually tapered into straight beak; beak 1 to 1.5 mm long; aperture deeply bidentate; hispidulous at margins and faces of beak.

Anatomy

Culm: In transverse sections culm broadly triangular with rounded corners; sides convex; specimens examined 3 to 5 mm long; with translucent spongy ground tissue towards centre, devoid of air cavity within ground tissue. Air cavities: only present at the peripheral region, having translucent aerenchyma within; just at the end of chlorenchyma, oval-oblong in outline, alternately arranged with the vascular bundles. Assimilatory tissue: as chlorenchymatous cells forming layers at the peripheral region of the culm, interrupted by both the air cavities and vascular bundles; air cavities surrounded by 2-3 cell layers at peripheral and 1-2 cell layers at central sides. Vascular bundles: as single row dense at the peripheral region and few other scattered towards centre; all total more than 50 in number; minor vascular bundles of peripheral
region embedded within chlorenchyma tissue, major partially embedded in ground tissue; all
mostly oval, with 2-8 conspicuous large metaxylems in three direction, either in group or singly;
sclerenchyma present on both the ends of vascular bundles, peripheral vascular bundles with
sclerenchymatous girder, extending upto the epidermal layer; minor vascular bundles with 2-3
cell-layers of sclerenchyma. Sclerenchyma tissue: associated with vascular bundles, some as free
patches present at the peripheral region, forming securiform to triangular girder only; in
peripheral vascular bundles sclerenchymatous girders baculiform and in central vascular bundles
crescentiform; all the other vascular bundles of ground tissue surrounded by crescentiform
sclerenchyma, patches of nearly triangular sclerenchyma tissue present opposite to minor vascular
bundles of peripheral region.

Leaf: Leaf blade in transverse section inversely W-shaped or flanged, dorsiventral; keel
prominent and protruding on abaxial side; keel acute to rounded; lamina thickest near the median
portion and gradually tapering towards edge; specimens examined 7 to 8 mm long. Epidermis:
daxial cells larger than abaxial cells; adaxial cells oblong to barrel-shaped; size of cells variable
in both the epidermis; cell size quite smaller at the point of attachment of sclerenchymatous
girders; adaxial cells largest at hinge region; hinge cells 11, most of the adaxial cells bulge to give
rise to bulliform cells; abaxial epidermis devoid of bulliform cell; cuticle thick in adaxial
epidermis; devoid of distinct palisade cells; none of the epidermis adnored by papillae or prickle.
Sclerenchyma tissue: generally associated with vascular bundles; in hinge region sclerenchyma
forms girder at abaxial side and connected with the abaxial epidermis; girders winged-
crescentiform or Y-shaped and adaxial sclerenchyma cap like; in keel region sclerenchyma forms
girder on both sides of vascular bundles, extending up to the epidermal layers; abaxial one
baculiform, massive and adaxial one crescentiform; in minor vascular bundles sclerenchyma
forms 2-3 cell layers surrounding the vascular bundles; sclerenchyma layers also present at
adaxial side of margins. Mesophyll: as chlorenchyma tissue, well developed, extending from
adaxial epidermis to abaxial one, interrupted by air cavities and vascular bundles; cells round to
oval in shape. Air-cavities: alternate to vascular bundles, rectangular to oblong in outline, with
oblong to nearly rectangular-tetrangular aerenchyma cells, surrounded by chlorenchyma cells.
Vascular bundles: all in single row, 18 in each half of lamina, 9-10 major and the other minors,
equidistant from epidermal layers, oval in shape, with 2-6 large metaxylems placed in 3-
directions, 2 always single and rest in groups. Sclerenchyma tissue: on each pole of major vascular bundles forming grider or just surrounding the minor vascular bundles; bundle sheath double cell-layered thick, interrupted by sclerenchyma. Bulliform cells present on adaxial epidermal layer, with bulged structure.
Fig. 85. Habit and inflorescence of Carex condensata
A. Habit (lower and middle part); B. Inflorescence (diagrammatic).
Plate XXXVIII. Photographs of habit and inflorescence of Carex condensata
1. Habit; 2. Inflorescence (magnified in part).
Plate XXXIX. Photographs of habitat condition of *Carex* spp.

1. and 2. Mixed population of *Carex continua* and *C. condensata*
Fig. 86. Morphology of glumes, gynoecium and utricle of *Carex condensata*

A. 1st sterile glume; B. 2nd sterile glume; C. fertile female glume; D. Gynoecium;
E. Immature utricle with style and stigma; F. Mature utricle; G. and H., Male glumes.
Fig. 87. Anatomical features culm of *Carex condensata*

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 88. Anatomical features leaf of Carex condensata

A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral part(cellular); D. Laminar edge(cellular).
Plate XL. Microphotographs of anatomical features of culm and leaf of *Carex condensata*

1. T. S. of culm; 2. and 3. a portion of culm (magnified); 4. T. S. lamina (one half); 5. Laminar groove; 6. Laminar lateral portion and edge. Scale bar - 1 and 4 (300 µm); 2, 3 and 6 (200 µm); 5 (80 µm).
B. Carex L. subgenus Carex

This subgenus is characterized by the following features:
Perennial herbs. Rhizomes stoloniferous or without stolons. Spikes few to numerous, unisexual, or both unisexual and bisexual, rarely all bisexual; bisexual spikes usually androgyneous, sometimes gynaecandrous, rarely single and terminal, usually arranged in spicate, racemose, or paniculate inflorescence; cladophyll sheath-like, without flowers; style slightly slender, base thickened or not thickened; stigmas usually 3, rarely 2. Utricles trigonous, plano-convex, or biconvex. Nuts trigonous, plano-convex, or biconvex.

Key to the sections of the subgenus Carex

1a. Peduncles 1-3(4) per flowering node, gradually decreasing in length towards apex..............2

1b. Peduncles to each flowering node more than 5, sometimes reaches up to 28; peduncles of different length.................................................................................................................................8

2a. Terminal spike either totally male or variable in sexuality........................................................3

2b. Terminal spike androgyneous or totally male .................................................................5

3a. Lower peduncle distantly placed, longer; all the male glumes and basal few female glumes long aristate......................................................................................................................... VIII. C. section Debiies

3b. Lower peduncle not so distantly placed, shorter; both male and female glumes not ariatate ... ................................................................................................................. IX. C. section Molliculae

4a. Bracts not sheathing; spikes shorter; plants smaller; veins of utricles distinct; stigmas 3 ...
................................................................................................................................. 179

4b. Bracts sheathing; spikes longer; plants longer; veins of utricles not distinct; stigmas 2
.................................................................................................................................................. X. C. section Forficulae

5a. Spikes developed just from very few cm above the ground level; multiple modules within a common cluster of leaves; stigma very short, recurved ...................... V. C. section Radicales
5b. Spikes developed not from the ground level; single module in a leaf cluster; stigma long, not recurved ................................................................. 6

6a. Leaf-blades more wide, to 7 mm; spikes elongated; utricles hispidulous (except beak), biconcave-flattened; stigmas 2 ................................................ XI. C. section Graciles

6b. Leaf-blades narrow, to 2.5 mm; spikes comparatively shorter; utricles not hispidulous (except beak), trigonous, stigmas 3 ........................................................................................................ 7

7a. Lowest flowering node often more distant; spikes 30-35 per module; wings of female glumes subequal ................................................................. III. C. section Hirtae

7b. Lowest flowering node not so distant; spikes 5-7(9) per module; wings of female glume equal ........................................................................ IV. C. section Mitratae

8a. Spikes stout, comparatively shorter, length of spike not related with sexuality of spike, even if male spike found with shortest length; nuts distinctly stipitate .............................................................. VII. C. section Hymenochlaenae

8b. Spikes lax, weaker, longer; maleness increases with the increase of length of spikes (longest spike totally male); nuts not stipitate .................................................. VI. C. section Decorae

This section Hirtae is characterized as follows:

Rhizomes sometimes stoloniferous. Involucral bracts leafy or the lowest leafy and upper setiform. Spikes unisexual and bisexual; upper spikes congregated, sessile; lowest spike rather remote, more or less pedunculate; male spikes usually 2–6; female spikes 2–7, densely arranged, many-flowered, sometimes with male flowers at upper part. Female glumes mucronate or aristate at apex. Stylar base not thickened; stigmas 3. Utricles membranous, white-hispidulous, with short beak; orifice emarginate.

Key to the species of the section Hirtae:

1a. Lowest flowering node not so distant; 5-7(9) spikes per module; wings of female glume equal............................................................................................................................11.C. inanis

1b. Lowest flowering node often more distant; up to 30-35 spikes per module; wings of female glumes subequal.........................................................................................................12.C. setigera


Description (Figs. 89-93; Pls. XLI-XLII)

Morphology

Vegetative morphology: Perennial herb, 15 to 30 cm long, phyllopodic, caespitose, with tufts of 50-100 modules per plant or genet, never stoloniferous; loosely tufted or matted. Roots light-brown to dark-brown. Ground level or underground stems bulbous, rhizomatous, not developed horizontally or vertically; rhizomes develop from lateral offsets not from elongated stolon. Leaves inserted on the lower half of the aerial stem or culm, in a basal tufts, existing for a single season or even less; sheaths of basal leaves persisting and breaking down into weak fibrils.
built up a conspicuous, stiff, purplish brown at the base of the plant; blades longer than the culm, sometimes twice as long as culm, 20 to 35 cm long, rare often up to 45 cm long and 1.5 to 2.5 mm wide, filiform-linear, margin scabulous, V-shaped in cross section; veins not prominent.

**Reproductive morphology:** Plant monoecious; culm 15 to 20 cm long, much shorter, or nearly half or less of the length of leaves; flowering nodes 3-5 per module; leaves 3 to 5, or 4-7 in immature plant clustered at the base; upper half of culm devoid of leaf; bracts leafy, basal in position to the inflorescence, conspicuous, much exceeding the inflorescence top. 20 to 25 cm long, with sheath much shorter than the blades; lower sheath 10 to 12 mm long, persistent; upper gradually decreasing in length and breadth; cladophyll absent. Inflorescence spicate; spikes 4-7, single in each node, crowded on apex, erect, 2 to 6 cm long; lower spikes distantly placed, with very short peduncle; peduncles 1 to 2 mm long, remain hidden in bract-sheath when young; lower and top skikes often longer; middle 2-3 comparatively shorter; spikes strongly erect, ovate to oblong-linear in outline; lower 4-6 spikes androgyinous; topmost one either totally male or with very few basal female flowers; glumes and flowers both 25-75 per spike; sometimes basal 2-3 glumes and upper 4-5 glumes sterile, otherwise fertile; glumes in close set, spreading at maturity; individual spike sub-sessile, grey-green. Pistillate portion in androgyinous spike distinct, 3 to 10 mm long; female flowers 30-60; female glumes equaling or slightly exceeding the utricles. 2.5 to 3.5 mm long, deciduous at maturity; all glumes ovate-elliptic, acute, sometimes acutely emerginate; 1-2-veined; midrib projecting slightly beyond the apex, margins orange-brown; middle portion hyaline-green; apex of some female glumes truncate; emerginate portion with some bristles; upper half of glumes with brown tinged patches, glabrous; stylar base not bulbous, gradually tapering towards apex; stigmas 3, surface projected. Staminate portion in androgyinous spikes not conspicuous; lower 4-6 spikes with very short terminal male section, densely cylindric, sometimes with 1-2 short basal branches, 2-3 mm long; male flowers 4-10; male glumes narrowly oblanceolate, 4.5 to 5 mm long, midrib keeled and produced into shortly excurrent tip, distinctly 1-3-veined; 2-3 incomplete veins on each side of male glumes; glabrous; stamens 3, rarely 2. Male spikes terminal, long cylindrical, 5 to 1.5 cm long and 25 to 80- flowered, rarely with basal 3-4 female glumes. Utricles knobbly, broadly ellipsoid to narrowly obovoid-trigonous, 2 to 2.25 mm long, not stipitate, spreading at maturity, 2-3-veined; upper half densely covered with short, stiff hairs; abruptly constricted into short beak; beak less than 0.5 mm long, slightly bidentate.
olive-brown. Nuts ovoid, trigonous and triangular in cross section, with rounded angles. 0.75 to 1mm; partially covers utricle; narrowed much at apex, dark brown to light brown.

**Anatomy**

Culm: triangular in cross section with rounded corners, without papillate extension on epidermal layer; margins convex, studied specimens 1cm long. Ground tissues towards the center translucent, spongy, devoid of air cavity. Air cavities present in the peripheral region only, oblong in outline, with oval to rounded aerenchyma cells within it, alternately arranged with vascular bundles, well surrounded by chlorenchyma cells. Assimilatory tissue: chlorenchyma cells well developed, arranged in 5 to 7 rows in the peripheral regions, interrupted by the air cavities as well as vascular bundles; cells oval to oblong, smaller in size than ground tissue. Vascular bundles: nearly 40, distributed in two complete and one incomplete rings, 18 minor and rest major, arranged in peripheral region, rare often very few vascular bundles also present towards center; with 2 to many large metaxylems; Sclerenchyma tissue: associated with vascular bundles; sclerenchyma cells on both the ends of vascular bundles and forming sclerenchymatous girder; girder securiform in peripheral vascular bundles and baculiform in central vascular bundles; 2 to 3-layered thick sclerenchymatous cells surrounding the minor vascular bundles; sclerenchymatous layer present around the vascular bundles of ground tissue; vascular bundles oval to round in shape.

Leaf: Lamina V-shaped in cross section showing dorsiventral nature, thickest at the keel and median portion of laminar portion and tapering towards the margins; apex of margins acute; keel protruding and rounded at the abaxial portion. Specimen examined about 2mm long. Epidermis: adaxial epidermal cells larger than abaxial cells, devoid of papillate extension; hinge portion made up of only 5 bulliform adaxial epidermal cells, oblong in shape and slightly larger than others; epidermal cells resting upon the sclerenchymatous girder smaller in both adaxial and abaxial layers. Mesophyll tissues: chlorenchymatous, well developed and present in entire leaf but interrupted by the presence of vascular bundles and air cavities; cells oval to round or to polygonal and comparatively smaller; Sclerenchymatous tissue: associated with the vascular bundles and forming girders of major vascular bundles; sclerenchyma girder horizontal, girders
smaller and thin in abaxial side, crescentiform to baculiform; girders extended upto the adaxial and abaxial epidermal layer; sclerenchymatous cells 2 to 3-layered thick and surrounding minor vascular bundles. Vascular bundles: in a single row, only 8 in one half of the lamina, 3 to 4 major and the others minor, placed at equidistance from the epidermal layer; vascular bundles with 2 single metaxylems side by side and group of 3 to 4 metaxylem cells at the adaxial portion or the tip portion; bundle sheath cells double layered, the outer parenchymatous and the inner sclerenchymatous and interrupted by sclerenchyma cells. Air-cavities: rectangular to oblong in outline; aerenchyma cells oval to rectangular within it and surrounded by well developed chlorenchyma cells. Bulliform cells only on the adaxial epidermal layer.
Fig. 89. Habit and inflorescence of *Carex inanis*

A. Habit; B. Inflorescence (diagrammatic—showing arrangement of flowers).

[Diagram showing male, female, and sterile flowers]
Plate XLI. Photographs of habit and inflorescence of *Carex inanis*

Fig. 90. Morphology of female glumes of *Carex inanis*

A. 1\textsuperscript{st} fertile female glume; B. 2\textsuperscript{nd} fertile female glume; C. 3\textsuperscript{rd} fertile female glume; D. 4\textsuperscript{th} fertile female glume; E. and F. Fertile female glumes from middle of spike; G. and H., Fertile female glumes from top portion of spike.
Fig. 91. Morphology female flower, utricle, nut and male glumes of *Carex inanis*

A. Utricle with style and stigma; B. Mature utricle; C. T.S. of utricle; D. Nut; E. and F., Male glumes from basal portion; G. and H., Male glumes from middle portion of spike.
Fig. 92. Anatomical features of culm of Carex inanis

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 93. Anatomical features of leaf of *Carex inanis*

A. T. S. of Lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate XLII. Microphotographs of anatomical features of culm and leaf of *Carex inanis*

1. T. S. of culm; 2. A portion of culm (magnified); 3. T. S. of lamina; 4. Laminar groove; 5. Laminar lateral portion. Scale bar- 1 and 3(200μm); 2, 4 and 5(50μm).

**Description** (Figs. 94-98; Pls. XLIII-XLV)

**Morphology:**

**Vegetative morphology:** Perennial herb, 45 to 60 cm high, caespitose, phyllopodic, monoeocious with solid stem; densely tufted with 30-35 modules per genet and matted. Roots light brown, tomentose. Ground level and underground stems horizontal, extensively spreading, stoloniferous; stolons 5 to 7mm long; aerial stem erect, more or less terete in outline, glabrous. Leaves 3-5, inserted along lower half of the culm, in basal tufts; leaves 7-9 in younger modules, existing for a single season or less; sheaths of basal few leaves dark purplish brown, splitting into stout reticulate fibrils; initial 2-3 leaves bladeless; forming a conspicuous build up at base of culm; leaf blades longer than culm and also exceeding the inflorescence top, 50 to 100 cm long and 1.5 to 2.5 mm wide, filiform; veins not prominent, but 3-4 faint veins on each side of the middle one, margins scaberulous.

**Reproductive morphology:** Plant monoeocious. Culm 25 to 40 cm long, shorter than leaf blades; flowering nodes 3-5 per module. Leaves clustered at the base of culm, absent in the upper half of culm; bracts basal the inflorescence; lower bracts leaf blade like, greatly exceeding the inflorescence top, 35 to 40 cm long and 1.5 to 2 mm wide at middle; lower bract longest; bract-sheath distinct at least in lower one, 5-6 cm long, persistent, in the upper nodes gradually decreasing in length and wideness. Inflorescence 15 to 20 cm long, paniculately branched or paniculate spiked; spikes 7-10, erect, overtopping, number sometimes reaching to 37; upper mostly sessile, lowest on peduncle, 0.8 to 4.2 cm long, excluding ensheathed portion; upper 1-4 totally male, or rarely with a few female at base; others either totally female or androgynous; peduncle generally one per node or very rarely two, hidden within leaf sheath when juvenile; basal spikes comparatively shorter, terminal one longest in each and every node, flowers 60-100 per spike; sterile glumes absent; glumes compactly arranged, spreading at maturity. Pistillate portion distinct, basal in androgynous spike(s), 0.5 to 2.5 cm long, commonly 10 to 12, rarely more as 100 to 120-flowered; female glumes longer than utricles, 4 to 4.5 mm long, oblong to
lanceolate, awned as 1 to 1.5 mm long, orange-brown with hyaline margins near apex; midrib keeled, projected in scabrid awn, single veined; stylar base not dilated; stigmas 3, as long as style with irregular projections. Staminate portion conspicuous, very compact, comparatively shorter in androgynous but longer in male spikes; 50 to 100-flowered per spike; male glumes oblanceolate, 1-3-veined, apiculate, light brown, glabrous; stamens 3; 3 to 3.5 mm long; filaments as long as anthers, 1 to 1.5 mm; anthers linear to linear-oblong, unequal, 1 to 1.5 mm long, apiculate with projection. Utricles ellipsoid-trigonous, narrowed at both the ends, 3 to 3.7 mm X 1 to 1.5 mm, slightly stipitate; stalk less than 0.5 mm long; loosely arranged with the axis, spreading at maturity, 4-5-veined, upper 2/3-3/4 densely covered with short, stiff hairs, gradually tapered to beak; beak short, 0.5 to 0.75 mm, slightly bidentate, olive-green. Nuts ellipsoid, trigonous, angles rounded under cross section, about 1.75 X 1.0 mm; narrowed much at base, dark brown.

**Microcharacters (SEM study):** Utricles: Intercostal cells rectangular with divergent apical papillae and collapsed cell wall; costal cells narrower, more elongated but also with thin, collapsed concave wall. Nut surface: all cells of proximal, distal and central regions mostly hexagonal, some polygonal; proximal cells more elongated, median cells orbicular; all cells having central, single silica body; basal platform concave in all cases with ornamentation: central body distinctly raised, not pointed and with blunt end; radial bars present; devoid of satellite body; periclinal wall distinct in the median portion of nut.

**Anatomy**

Culm: More or less circular with wavy outline in transverse section. Specimen examined 2 mm long. Translucent ground tissues towards the center; cells polygonal to oval, with variable sizes, bigger at the central portion. Air cavities: present at the peripheral region only, alternate to the vascular bundles, circular in out line, with translucent, oval to oblong shaped cells, and surrounded by chlorenchyma cells. Assimilatory tissue: chlorenchyma cells at the peripheral region, in 11 to 13 layers; cells of the chlorenchyma smaller than the ground tissue and polygonal in shape and variable in size; continuity of the chlorenchyma layer interrupted by air cavities, vascular bundles and sclerenchyma girders. Vascular bundles: distinctly in two rows; first row in peripheral region embedded particularly within the chlorenchyma and as many as 34; second row embedded in ground tissue and as few as 9; in first row 17-19 major vascular bundles and the rest
minor vascular bundles arranged alternately; all the major vascular bundles at peripheral region having adaxial girder extended up to epidermis; vascular bundles of second row surrounded by sclerenchyma cells; 2 large metaxylem arranged side by side and 2-3 metaxylems grouped together slightly above the 2 large metaxylems. Sclerenchyma tissue: on both sides of the vascular bundle; shape ranging from oval to circular; vascular bundles always associated with sclerenchyma. Sclerenchyma forming girder in peripheral vascular bundles; peripheral girders baculiform and extended upto epidermis and the central sclerenchyma crescentiform; in the vascular bundle of the ground tissue sclerenchyma present on both sides of the bundle in 2-3 rows and surrounding the vascular bundles, crescentiform in shape.

Leaf: Flat V- shaped in cross-section; keel prominent, not protruding at the abaxial side, apex of keel rounded; lamina thick in middle of each half and thin in midrib region and abruptly tapering towards the margins; tip of margins slightly rounded. Epidermis: adaxial epidermal cells larger than the abaxial cells; cells shortly barrel-shaped-oblong in both the surfaces, size of cell variable in both the cases; cells quite smaller over the sclerenchyma girder, papillate adaxial epidermal cells present; adaxial cell quite larger in hinge portion; hinge cells nearly 6 in number; the cuticular layer thick on adaxial layer while thin in abaxial layer. Mesophyll tissue: chlorenchyma well developed, extended from adaxial to abaxial epidermis; continuity of the chlorenchyma tissue interrupted by the presence of air-cavities and vascular bundles; cells rounded to oval and variable in size. Air-cavities: oblong in outline with translucent, oblong-round-polygonal aerenchyma cells, surrounded by chlorenchyma cells. Sclerenchyma tissue: associated with the vascular bundles; present on both side of vascular bundles and forming girder in case of major vascular bundles; adaxial girders secure-baculiform and abaxial girders mostly crescentiform; the minor vascular bundles with 1-2 layers of sclerenchyma cells. Vascular bundles: always arranged in a single row, arranged alternately as major and minor; number of vascular bundle 6 to 7 in each half the lamina, 3-4 major and the rest minor; major always oval and minors sometimes circular; vascular bundles surrounded by sclerenchyma cells: minor vascular bundles near to adaxial epidermal layer and major equidistant from adaxial and abaxial epidermal layer; vascular bundles always with 2 to 7 metaxylems; 2 lower single and distant apart and upper one multiple in number and in single group; bundle sheath double layered as outer parenchymatous and inner sclerenchymatous around the vascular bundle; major vascular bundle interrupted by sclerenchyma cells at both adaxial and abaxial sides and complete circle in minor vascular bundle.
Fig. 94. Habit and inflorescence of *Carex setigera*

A. Habit; B. Inflorescence and arrangement of flowers on spike (diagrammatic).

[Diagram showing habit and arrangement of flowers]
Plate XLIII. Photographs of habit and inflorescence of Carex setigera
1. Habit; 2. Lower portion of plant; 3. Inflorescence (magnified in part).
Fig. 95. Morphology of female glumes, female flowers, utricle and nut of *Carex setigera*

A. and B., Female glumes; C. Immature utricle with style and stigma; D. Utricle; E. Nut;
F. T.S. of nut.
Fig. 96. Morphology of male glumes and stamens of *Carex setigera*

A. and B. Male glumes from basal portion of spike; C. Male glume from top portion of spike; D. Stamens.
Plate XLIV. Scanning electron microphotographs of utricle and nut of Carex setigera

Fig. 97. Anatomical features of culm of *Carex setigera*

A. T. S. of culm (diagrammatic); B. A portion of culm (cellular).
Fig. 98. Anatomical features of leaf of *Carex setigera*

A. T. S. of Lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar margin(cellular).
Plate XLV. Microphotographs of anatomical features of culm and leaf of Carex setigera
1. T. S. of culm; 2. A portion of culm (magnified); 3. T. S. of lamina; 4. Laminar groove; 5. and 6. Laminar lateral portion. Scale bar-1 and 3(200μm); 2, 4, 5, 6(50μm).

This section is characterized by the following features:

Spikes usually of unisexual flowers; terminal spike male; lateral spikes often female, rarely androgynous; female spikes long, cylindric, or linear. Stigmas 3 Utricles herbaceous, glabrous or puberulent, shortly beaked or nearly beakless; orifice truncate or 2-toothed. Nuts tightly enveloped, trigonous, sometimes with contracted angles and excavated faces, apex often discoid-annulate.


Description (Figs. 99-102; Pls. XLVI-XLVIII)

Morphology

Vegetative morphology: Perennial herb, 30-60 cm high, caespitose, phyllopodic. about 100 modules per plant, monoecious, densely tufted. Roots dark brown. Stems ground level or underground, not developed horizontally, rarely as 2-3 cm long stolon developed; rhizomes arising from lateral offsets. Leaves inserted on the lower 2/3 part of the plant, generally in basal cluster, existing for a single season or less; leaves of immature plants much longer than mature one; leaf-sheath basal, persistent, at maturity breaking down into weak fibrils, no reticulate fibres of the sheath formed but forming a conspicuous pale brown structure at the base of plant; bladeless sheath generally absent, or rarely 1-2 at base; leaf-blades much shorter to nearly equaling the top of inflorescence, never exceeding top of inflorescence; 25 to 35 cm long and 1.9 to 2.7 mm wide; leaves with distinct sheath and blades, 1-2 on the lower half of culm, filiform, linear, nearly V-shaped in cross section; veins not prominent, 2-3 on each side of mid vein; margins slightly scaberulous.

Reproductive morphology: Plant monoecious; culms 22 to 45 cm long, nearly equaling the leaf top; module with 4-7 flowering nodes; leaves 3-6, clustered at base of culm; upper half of culm sometimes with 1-2 leaves; lower 2-3 bracts leafy, much more exceeding the inflorescence top, lowest one 17 to 27 cm long, as wide as foliage blade; base sheathing; lowest sheath longest.
as 5 to 7 mm long, persistent; in upper nodes gradually decreasing in length and wideness. Inflorescence of 4-5 or rarely 7, overtopping sub-sessile spikes; crowded at the top of culm, 3 to 7 cm long; single spike sessile to sub-sessile; lowest spike placed slightly distant, 0.7 to 2.7 mm away from second one; pedicels very short, 1.5 to 12mm, remain hidden in young condition within bract-sheath for lowest one only; lower 1-2 spikes longer, 15 to 19 mm long; median comparatively shorter and upper topmost one longest, 20 to 25 mm long, strongly erect, oblong-cylindrical; lower all female or androgynous, topmost one totally male; flowering glumes 30-60 per spike; glumes in close set, spreading and light brown at maturity. Pistillate portion in androgynous spike distinct, predominant, 10 to 15 mm long; flowering glumes 30-50; female glumes equaling to or slightly exceeding the utricle, 2 to 2.5 mm long, duciduous at maturity; sterile glume absent; ovoid-oblong, sometimes minutely emerginate, 1-3-veined, truncate, apex bristled, otherwise glabrous, dark brown spots along midvein; style 0.7 to 1.2 mm long, linear, base slightly dilated; stigma 3, as long as style, curved, surface irregularly projected. Staminate portion in androgynous spike and in all lower spikes, inconspicuous, 3 to 4 mm long, 5-12-flowered; male glumes ovate, elliptic to oblanceolate, single-veined, 3.5 to 4.2 mm long. upper half of glumes slightly winged, with light brown patches; stamens 3; filaments at maturity 3 to 3.5 mm long; male spike terminal, cylindric, 20 to 25 mm long, 55-70 rarely 75-flowered. Utricle suberect, knobby, ellipsoid-trigonous; 1.8 to 2.3 mm long, gradually tapered towards apex, scarcely beaked, surface covered with short, stout, densely scattered hairs, pale green; aperture shallowly notched; beak very short, 0.2 to 0.6 mm long; veins indistinct. Nuts ovoid-trigonous, triangular in cross section; angles rounded; 1 to 1.5 mm long, closely filling the utrices, much narrowed at apex, dark brown to blackish brown.

Microcharacters (SEM study): Utricles: costal and intercostal cells of utricles undifferentiated; epidermal cells with papillate structure, with collapsed thin, concave outer walls. Nut surface beeded; stalk cells devoid of silica bodies, elongated, rectangular to polygonal in outline; all cells of proximal (except stalk) and distal half polygonal (mostly hexagonal) with single central silica body; basal platform of silica body concave to plano-concave, ornamented; central body conical, apex pointed, comparatively prominent and larger; periclinal wall present; satellite and secondary silica body absent.
Anatomy

Culm: Triangular with two rounded corners and one acute corner. Studied specimens 0.1 to 0.2 mm long. Translucent ground tissue almost absent. Air cavities: present in between the vascular bundles, irregular in outline, of rare occurrence, surrounded by sclerenchyma of vascular bundles. Chlorenchyma cells least in amount at the peripheral regions only. Vascular bundles: 32-34, each one very close and attached with each other by the sclerenchymatous tissues, compactly arranged either in groups or single in triangular fashion. Sclerenchyma tissue: present around each vascular bundle; the peripheral sclerenchymatous cells form adaxial girder and securiform in structure; sclerenchymatous cells associated with all the existing vascular bundles and surrounding the vascular bundles.

Leaf: Lamina V-shaped outline in cross section, margins slightly flanged; keel protruding and rounded, dorsiventral. Epidermis: adaxial epidermal cells having some papillate extension and having some silica bodies; specimen studied generally 0.4-0.5 cm long; lamina thickest towards the median portion of each half of lamina and finally tapered towards margins; tip rounded; the adaxial epidermal cells larger than the abaxial ones; cells oval to barrel-shaped; variable in size, bulliform cells larger; epidermal cells quite smaller above the sclerenchymatous girder in both epidermal layers; cuticle thick on adaxial surface but thin on abaxial surface; hinge region made up of 6-8 adaxial bulliform epidermal cells, single-layered, thick, sometimes not separable from other adaxial epidermal cells. Sclerenchyma tissue: associated with the vascular bundles; in the hinge portion sclerenchyma forms girder both at the adaxial and at the abaxial epidermal layers; adaxial sclerenchyma cap-shaped and 1-2 cell-layered thick; vascular bundles of the median portion and other major vascular bundles both having sclerenchymatous girder on both the ends of the vascular bundle extending upto adaxial and abaxial epidermal layer; shape of girder crescentiform, securiform to baculiform or Y-shaped; in terminal or marginal vascular bundle and in other minor vascular bundles having 1-2 cell layers of sclerenchyma. 10-12 layers of sclerenchyma present at the adaxial portion of the margins, opposite to marginal vascular bundles, not connected with any of the vascular bundles. Mesophyll tissue: of chlorenchyma cells well developed, but interrupted by air cavities and vascular bundles; cells oval to rounded in shape and of variable sizes; Vascular bundles: 10-12 (4-5 in each half of the lamina), 2-3 minor
and other major, arranged alternately; sclerenchyma cells present on both the poles of vascular bundles forming adaxial and abaxial girders; vascular bundles with 2-4 or 6 large metaxylems, arranged in triangular fashion as 2 sides by side and others above the two in one group; vascular bundles oval in shape, with single layered sheath and with interruption of sclerenchyma cells at both adaxial and abaxial sides. Air-cavities: present alternate to vascular bundles, long rectangular with rounded corners in outline; aerenchyma cells within air-cavity rounded to oval-shaped; Bulliform cells: 6-8 in number, single-layered present only in the adaxial layer, rounded.
Fig. 99. Habit and inflorescence of *Carex breviculmis*

A. Habit; B. Inflorescence with arrangement of flowers (Diagrammatic)

- Male flower
- Female flower
- Sterile flower
Plate XLVI. Photographs of habit and inflorescence of *Carex breviculmis*

1. Habit; 2. Inflorescence (magnified in part).
Fig. 100. Morphology of female glumes, utricle, female flower, nut, male flower of *Carex breviculmis*

A. and B., Female glumes; C. and E. Utricles; D. Stigmatic surface; F. Nut;
G. T.S. of nut; H. and I. Male glumes.
Plate XLVII. Scanning electron microphotographs of utricle and nut of *Carex breviculmis*

Fig. 101. Anatomical features of culm of *Carex breviculmis*

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 102. Anatomical features of leaf of *Carex breviculmis*

A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate XLVIII. Microphotographs of anatomical features of culm and leaf of *Carex breviculmis*

1. T. S. of culm; 2. A portion of culm (magnified); 3. T. S. of lamina; 4. Laminar groove; 5. Laminar lateral portion; 6. Laminar edge (margin). Scale bars: 1 and 3 (200 μm); 2 and 4 (150 μm); 5 and 6 (50 μm).
V. Carex sect. Radicales (Kukenthal) Nelmes in Reinwardtia 1: 389. 1951.


This section Radicales is characterized by the following features:

Involucral bracts leafy, longer than inflorescence, long sheathed. Spikes androgynous. 1 to several, usually remote; lowest spike borne from middle part or from the base of culm, rarely contiguous. Stylar base usually thickened, rarely not; stigmas 3. Utricles papery or subleathery, pubescent, hispidulous, or glabrous, usually ciliate along margins, many-veined, apex abruptly contracted into a short beak.


Description (Figs. 103-107; Plas. XLIX-LII)

Morphology

Vegetative morphology: Perennial herb, usually 30-45cm long, rarely 50cm long, caespitose, typically phyllopodic; modules 20-25 per plant, 2-8 or even 10 modules developed from a common ensheathing stem, very difficult to identify and separate the individual module: generally loosely tufted but modules originated from common rhizomes or stolons not separable. Root light brown, often tomentose. Underground rhizomes obliquely developed into an up and down fashion, not horizontal, hard, covered with tough pale to deep brown fibres as remaining of the sheath of previous 2-3 years; comparatively long, commonly 10-12cm, rarely up to 15cm long between two consecutive sets of modules, pale to deep brown, often horny, upright stems covered or ensheathed with bases of leaf-sheaths at basal part; sheaths pale brown, sometimes persisting as elongated fibres, sometimes leaf-sheath not fibrillose or not as reticulated fibres; leaf-blade portion stripped with distinct light brown veins; bladeless leaf-sheath of 3-5 also present at the base of the foliase leaf-sheath, reddish brown–pale brown, along with leaf-sheath forming a conspicuous, tightly attached structure at the base of a group of modules. Leaves mostly in stout elongated rosettes, 5-9 in number, just equaling the top of the inflorescence or somewhat overtopping by 3-5 cm; leaf-blades generally existing for single season but sheath persistent for...
more years, 45 to 50 cm long and 3.5-5.5mm wide, leathery, flat on both the surfaces, margins glabrous, rarely margins scabirulous in older blades, not folded, single mid-veined with 3-4 very prominent straitae on each side of the midvein.

**Reproductive morphology:** Plant monoecious; culms 1.5 to 2cm, rarely up to 35-37 cm long; more or less equal of leaves; flowering nodes 1 to 3 per module. Leaves 5-7(9) in rosette clustered at the base of the culm, usually at 1-3 basal nodes, absent in upper half of the stem; bracts leafy, basal in position to inflorescence; lower bracts alike to leaf-blades, equal to or slightly exceeding the inflorescence top; lowest one 9-22 cm long and 2-2.5mm wide at middle; bract-sheath short, distinct; lowest sheath 1.5-2cm long, persistent; in upper nodes gradually decreasing in length and breadth; cladophyll absent. Inflorescence multispicate on solitary culm, commonly 3-5-spiked, one to two on each node of the module; lateral spikes with very short peduncle of 3-5mm long, often not exerted from sheath and remaining hidden at young stage, placed unequally; lower often longer and the upper shorter, usually 10-15cm long below; each spike distichous, erect, not divergent or drooping, linear to linear-oblong in outline, probably protogynous; lower spikes comparatively shorter, 2.5 to 3.5 cm long; topmost one longest as 4.5-5.5cm long; lower sometimes nearly basal to the culm; generally 0.5 to 2.0cm above the ground level; all spikes androgynous; glumes commonly 25-40, rarely up to 55 per spike: basal 2-3 glumes very distantly placed, sterile; upper glumes comparatively in close set, never spreading or wide open. Staminate portion conspicuous, very compact, overlapped and imbricate; comparatively shorter as 12-22 mm long, 20-40-flowered; glumes ovate to broadly ovate, shorter, single mid-veined, slightly mucronate at apex; light brown, glabrous; stamens 3; filaments comparatively shorter, about 1.5 long, dilated at base; anthers linear to linear-oblong, unequal, 1.5-2mm long, posterior one comparatively slightly shorter, bluntly appendiculate or very apiculate at apex; crests without any projection. Pistillate portion distinct, 17-25mm long, commonly 10-16, rarely up to 20-flowered; female glumes encircling the spike axis, comparatively shorter than the utricle, 3-3.5mm, deciduous at maturity; lower 3-5 glumes very distantly placed, ovate, slightly mucronate at apex, multi-veined; 3 veins very distinct and 10-12 incomplete veins also present on each side; hyaline to light brown, glabrous; styal base bulbous, obclavate, comparatively longer, 1-1.7mm long, gradually tapering at apex with irregular glochidiate projections; stigmas 3, very short, 0.3-0.6mm long, surface muricate to glochidiate.
recurved after anthesis. Utricles ellipsoid to oblong-ellipsoid, 5-5.5mm long at maturity, distinctly stipitate; stalk to 0.7mm; loosely attached with the axis and spreading at maturity, more than 20-veined, upper half hairy and hispidulous, gradually tapered towards the beak; beak very short, 0.5-0.7mm long, bidentate; cariaceous, pale green. Nuts ellipsoid-trigonal, broadly globose, filling fully the utricle, 2.5-3mm, triangular in cross section, stipitate, surface reticulate, dark brown.

**Microcharacters (SEM study):** Utricle Surface differentiated into costal and intercostal regions; costal region made up of comparatively elongated cells; intercostals cells inconspicuous but reticulate. Nut surface with tetra-, penta- and hexa-gonal cells, alveolate cells generally devoid of silica body; a few cells with faintly raised single blunt ended silica body; basal platform of silica not clear; no evidence of the presence of satellite or secondary silica body.

**Anatomy**

**Rhizome:** Oval-subcircular in cross section; epidermis not projected; subepidermis with conspicuous, subcircular strands of fibre. Cortex unilateral, differentiated into an outer zone of upto about 10 layer of cells; cells thick-walled and inner zone usually wider, more spongy zone, composed of many layers; cells thin walled; outer zone consisting of thick-walled fibres or cells with slightly thickened walls. Cortex devoid of any cavity; outer cortex up to 10 layers of polygonal cells; slightly thick walled, heterodiamicetric, changing over abruptly to inner cortex; inner cortical cells up to 18 cell-layered thick; cells rounded, comparatively smaller. Endodermal layer one celled, some areas with 2-3-celled thick, sometimes wavy. Stele oval, closely packed, amphivasal vascular bundles surrounding very small pith; medallary rays radiating.

**Culm:** In transverse section culm irregularly triangular in outline; corners irregular; translucent ground tissue absent. Air cavities: present in between the vascular bundles; cavities triangular to broadly triangular in outline. Assimilatory tissue: inconspicuous or almost absent in the peripheral region. Vascular bundles: 25-33 in number, oval in shape, attached with the sclerenchyma girders at both the ends of vascular bundles, compactly as well as irregularly arranged due to absence of soft tissue of the studied specimens. Sclerenchyma tissue: forming the adaxial girder at peripheral side, crescentiform or triangular in outline; sclerenchyma attached in
the form of peripheral and central girders for major vascular bundles of peripheral region and surrounding the other vascular vascular bundles; sclerenchyma cells of one vascular bundle often associated with the adjacent one.

Leaf: Lamina in transverse section inversely W-shaped; dorsiventral; margins flanged; keel prominent with rounded tip; tip protruding towards abaxial side, forming a prominent ridge on abaxial side and groove on adaxial side; keel not terminated by any silica body; lamina thickest in between the keel and margins and gradually tapered towards both ends as margins; tip of margins rounded; specimens examined usually 5 to 7.5 mm long. Epidermis: adaxial epidermal cells longer than abaxial epidermal cells, usually 3-4 times or even more, asymmetrical in size and shape, with prominent bulliform cells; adaxial epidermal cells at the point of attachment of sclerenchyma girders quite smaller also as in case abaxial epidermal cells; cells barrel-shaped; cells largest at the hinge region; hinge made up of 9-11 pallisade like vertically elongated cells; abaxial epidermal layer more or less uniform, made up of barrel-shaped cells; epidermal cells not generally adorned by any papillae or prickles. Sclerenchyma tissue: always in patches, generally associated with vascular bundles, sometimes as separate patch; in hinge region sclerenchyma form girder on abaxial side, 5-7 cell-layered, remaining attached with the abaxial epidermal layer, crescentiform; on adaxial side 1-2 cell-layered thick, forming a cap like structure on vascular bundle, never extended up to adaxial epidermal layer; the major vascular bundles situated in between median portion and the margins always connected with both adaxial and abaxial epidermal layers with the help of sclerenchyma girder; adaxial girder more massive, 13-15 cell-layered; abaxial girder crescentiform, 5-6 cell-layered; minor vascular bundles just surrounded by 1-2 cell-layered sclerenchyma, totally devoid of sclerenchyma girders; sclerenchyma at the margins on both sides of lamina just opposite to the last vascular bundle 5-7 cell-layered thick; sclerenchyma patches 45-50-celled, oval to nearly rounded, not connected with the vascular bundles. Mesophyll: undifferentiated, homogenous, extending from adaxial epidermis to abaxial side, interrupted by vascular bundles and aerenchyma of air cavities; chlorenchyma cells isodiametric, oval to barrel-shaped. Air cavities: occurring alternate to both major and minor vascular bundles, nearly rectangular, filled up with rectangular cells; sometimes in the form of rectangular-oval cavities, always surrounded by chlorenchyma tissue. Vascular bundles: 7-8 on each half or side of the lamina, all abaxial in a single row; major and minor vascular bundles
arranged alternately, equidistant from the epidermal layers as well as from the adjacent vascular bundles, all oval in shape, with 2-6 distinct metaxylems in 2-3 directions; larger metaxylems generally remain singly; major vascular bundles with sclerenchyma girder on each side; minor vascular bundles surrounded by sclerenchyma layers only; bundle sheath single to double cell-layered thick; outer parenchymatous and inner sclerenchymatous. Bulliform cells present only in the adaxial epidermis, bulged, comparatively longer, not papillate.
Fig. 103. Habit and inflorescence of Carex speciosa
A. Habit; B. Inflorescence with arrangement of flowers on spike.

- Male flower, Female flower, Sterile flower
Plate XLIX. Photographs of habit and inflorescence of Carex speciosa

1. Habit; 2. Lower portion of plant (with rhizome); 3. Inflorescence (magnified in part).
Fig. 104. Morphology of female glumes, female flower, utricle and nut of *Carex speciosa*

A. and B., Female glumes; C. Utricle; D. Nut(younger) with style and stigma; E. T.S. of nut; F. Nut surface magnified; G. Stigmatic surface.
Fig. 105. Morphology of male glume and stamens of *Carex speciosa*

A. Male glume; B. Androecium; C. Stamen.
Plate L. Scanning electron microphotographs of utricle and nut of *Carex speciosa*

1. Utricle and nut (partial); 2. Utricle surface; 3. Nut; 4. Surface of nut at middle portion; 5. Surface of nut at basal part; 6. Surface of nut at apical region. (sbs-silica bodies)
Fig. 106. Anatomical features of culm of Carex speciosa
A. T. S. of culm (diagrammatic); B. A portion of culm (cellular).
Fig. 107. Anatomical features of leaf of *Carex speciosa*

A. T. S. of Lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral part(cellular); D. Laminar edge(cellular).
Plate LI. Microphotographs of anatomical features of rhizome, culm and leaf of Carex speciosa

1-2 T. S. of rhizome; 3. A portion of rhizome magnified; 4. T. S. of culm; 5. A portion of culm magnified; 6. T. S. of lamina. Scale bar-1 and 6(300µm); 2-4(200µm); 5(50µm).
Plate LII. Microphotographs of leaf of Carex speciosa

1. T.S. of laminar groove; 2. Laminar lateral part; 3. Laminar edge. Scale bars: 1-3 (200μm)

This section is characterized by the following features:

Rhizomes short, or long creeping. Culms slightly stout. Leaves basal as well as cauline. Involucral bracts leafy, rarely setaceous, sheathing. Inflorescence forming a panicle; each partial branch of panicle with 2–7 spikes; terminal 1 or 2 spikes male; remaining spikes androgynous, with unequal peduncles. Female glumes pale brown, purple-red, or blood-red; stigmas 3. Utricles suberect, or obliquely patent, ellipsoid or ovoid-lanceolate, compressed-trigonous, glabrous, or hispid; beak long; orifice pale hyaline. Nuts oblong, or ellipsoid-obovoid, trigonous.

Key to the species of the section Decorae

1a. Glumes compactly arranged (except basal 2–3); both male and female glumes distinctly aristate or awned; base of the stem pale brown; leaves longer, much overtopping; bladeless sheath not found.............................................................................................. 15. C. daltonii

1b. Glumes loosely arranged; female glume not awned or aristate; base of stem deep red (glistening red); leaves shorter, throughout the stem and culm; bladeless leaf-sheath present even after maturity........................................................................................................ 16. C. insignis


Description (Figs. 108-111; Pls. LIII-LIV)

Morphology

Vegetative morphology: Perennial herb, 60-90 cm long, rarely attaining 1m high; phyllopodic, caespitose having 5-7 modules, monoecious; stem solid. Roots dark brown, slightly tomentose, loosely tufted. Underground stems rhizomatous; when horizontal stem develops, creeping, very short, usually 2 to 3 cm, hard stolon not developed. Leaves in basal tufts of 7-11;
bladeless leaf-sheath absent; base of leaf-sheath golden brown, shining, persisting, not breaking down into fibrous or reticulate structural remnants; leaf-sheath of previous 2-3 seasons also found to persist, blackish brown to dark-brown, shining; leaf absent in the upper half of the culm; leaf-sheath forming conspicuous spongy covering at the base of the plantlets; leaf blades 70-90 cm long and 0.5 to 12 mm wide; mostly overtopping the inflorescence top, W-shaped in cross section, surface and margin scabrous; midvein single, with 6-7 prominent lateral veins on each side of the midvein.

Reproductive Morphology: Plant monoecious; culms 30-50 cm long, much shorter than the leaf length; flowering nodes 5-9 per module. Leaves 4-5 in the upper part of the stem, glabrous, Inflorescence bracts leafy, associated with the base of the inflorescence; all exceeding much than the stem and or inflorescence, sometimes twice the length of the flowering stem, 20-25 cm long; leaf-sheath shorter than leaf blades, up to 13.5 cm long, persistent; bract-sheath prominent, 8-13 mm long and covering the lower part of the peduncles; peduncles remain hidden within the bract sheath in immature condition; lowest bract one, 25-28 cm long and 4-5.5 mm wide; bracts of the upper nodes gradually decreasing in length and wideness; all the bracts foliaceous; cladophyll absent, inflorescence forming paniculate structure with generally 2-4 or rarely 27-29 peduncles per node; 2-35 to 40 spikes per node; spikes dense, linear, 15-25 cm long; also forming multispicate, fasciculate structure; lateral spike sessile; individual spike divergent, variable in length with ranging from 1-20 cm; floral arrangement also variable; spikes of comparatively shorter length either totally composed of female flowers or a few with staminate flowers at its top; in medium sized spikes usually equal distribution of flowers as basal half with pistillate flowers and upper half with staminate flowers; longest spikes either totally staminate or very few as 1-2 pistillate flowers at the base; number of flowering glumes to spike also variable as ranging from 15-40; sterile glumes absent. Staminate flowers conspicuous; male glumes arranged spirally and compactly; number of staminate glumes very variable; staminate glumes ovate, 2 to 2.5 mm long, aristate; arista with dentatation, 5 to 6 mm long; median portion of the glumes light-brown to dark-brown, margins entire, hyaline, glabrous, single-veined; stamens 3, unequal in length; filaments in young condition 0.5-0.7 mm long; anthers linear-oblong, unequal in length; one longer, 2-2.5 mm; crests appendiculate, globular, head-like, covered with bristles. Pistillate portion variable, 11 to 20 mm long; number of pistillate flowers per spike also variable.
2-3 in longer spike to 40-45 in comparatively shorter spike; female glumes longer than the perigynia at young condition/while young, ovate, aristate; arista appendiculate; middle part reddish brown, lateral part hyaline, single-veined; mid-vein appendiculate, 4.25 to 5.5mm long, gradually decreasing length towards the top of spikes; style very short in young condition; stigma 3, comparatively longer, about 2.5 mm long; perigynia ellipsoid to lanceolate in young condition, about 2.5mm long, hispid, stipitate, erect, golden brown, veins on the surface not distinct, membranous, with very short beak; beak bidentate, 1.2 to 1.8mm long.

Anatomy

Culm: Triangular in transverse section, with rounded corners; epidermis wavy, not papillate; specimens about 5mm in long. Ground tissue towards the center, devoid of air-cavity. Air-Cavities: in the peripheral region, oblong in outline, filled with oval to rounded aerenchyma cells. Assimilatory tissue: chlorenchyma cells at the peripheral region of the culm interrupted by the presence of air-cavities and vascular bundles; Vascular bundles: in 4-5 rows; peripheral vascular bundles arranged in row and the other vascular bundles scattered within the ground tissue towards the centre, 60 to 80 in number; each one oval to rounded in shape, always with 2 to 8 large metaxylem in triangular fashion as 2 side by side and others above the two in one group. Sclerenchyma cells: present on both sides of vascular bundles and also associated with the vascular bundles; in peripheral vascular bundles adaxial sclerenchyma forming girder, extending up to the epidermal layer, T-shaped to baculiform; vascular bundles of ground tissue with crescentiform girder; minor vascular bundles associated with 2-3 sclerenchyma cells surrounding them.

Leaf: Lamina widely V-shaped in cross section, dorsiventral with protruding keel, tapering towards margins, acute; thickest in the median portion of each half of lamina; specimens usually 1-1.2 cm long. Epidermis: adaxial epidermal cells larger than abaxial cells, devoid of papillae on both the surfaces; cells resting upon the sclerenchymatous girder quite smaller in both the epidermal layers; cells oblong to barrel-shaped; in hinge portion the adaxial epidermal cells larger enough than other adaxial epidermal cells; hinge cells in two rows; first row 8-celled; cells long palisade shaped; second row 21-celled; cells oblong; the whole structure forming an oval to rounded shaped mass of cells; hinge region protruding and rounded on the abaxial surface.
Sclerenchyma cells: associated with vascular bundles, present on both poles of vascular bundles forming a girder, extending up to epidermal layers of both the surfaces; in major vascular bundles abaxial girders crescentiform and adaxial girders baculiform to Y-shaped; in minor vascular bundles, sclerenchyma cells of 1-2 layers surrounding the vascular bundles; sclerenchyma cells of 2-3 layers also present in adaxial part of the margin portion of lamina. Mesophyll tissue: well developed, interrupted by air cavities and vascular bundles. Air cavities: oblong to rounded in outline, filled within by the rounded to oval-shaped aerenchyma cells. Vascular bundles: present in single row, major and minor vascular bundles arranged alternately, 18 to 20 in number. 8-10 vascular bundles in each half of lamina; each one oval, with 2-3 large metaxylems; sclerenchyma cells present on both sides of minor vascular bundles; in major vascular bundles as sclerenchymatous girder attached with epidermal layers; bundle sheath single-layered, interrupted by sclerenchyma cells on both sides.
Fig. 108. Habit and inflorescence of *Carex daltonii*

A. Habit; B. Inflorescence (diagrammatic); B1-B4; Arrangement of flowers on spike.

- Male flower.  — Female flower.  — Sterile flower

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Male flower,  Female flower,  Sterile flower
Plate LIII. Photographs of habit and inflorescence of *Carex daltonii*

1. Habit; 2. Inflorescence (upper part).
Fig. 109. Morphology of female glumes, female flower, male flowers and stamens of *Carex daltonii*

A. 1st Female glume; B. 2nd Female glume; C. Female glume from middle of spike; D. Gynoecium; E. Male glume; F. Male flower; G. Stamens.
Fig. 110. Anatomical features of culm of *Carex daltonii*

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 111. Anatomical features of leaf of *Carex daltonii*

A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate LIV. Microphotographs anatomical features of culm and leaf of Carex daltonii

1. T. S. of culm; 2. A portion of culm (magnified); 3. T. S. of lamina; 4. Laminar groove; 5. Laminar lateral portion; 6. Laminar edge. Scale bar-1(300μm); 2, 3 and 6(200μm); 4 and 5(50μm).

Description (Figs. 112-115; Pls. LV-LVII)

Morphology

Vegetative morphology: Perennial herb, generally 60 to 90 cm long, population of the species occurred under shades sometimes reaching 160 to 170 cm high; aphyllopodic, caespitose, monoecious; stems solid, triangular, loosely to moderately tufted, 10-20 modules per plant. Roots pallid-brown. Stems of ground level and underground sometimes stoloniferous; stolons stout, elongated, 2.5 to 3.5 cm long, rarely reaching up to 6 cm, covered by torned scales; aerial stems erect, glabrous; lower 2.5-15 cm of 4-5 internodes covered by sheaths; sheaths 5-7, nearly bladeless, reddish to purplish; lower portion of the aerial stem also with persisting sheath; sheaths bladeless, reddish to purplish, not breaking in to fibrils, forming a conspicuous build up; aerial part of the stem also partially covered by leaf-sheath of foliage leaves; sheaths red-coloured; foliage leaves evenly distributed homogenously throughout, exceptionally along the comparatively longer culms; culms looking red by red-colored leaf-sheaths; leaves distinctly tristrichous; leaf-blades comparatively shorter, 19 to 35 cm long and 4 to 5.5 mm wide; straight in immature plant, slightly spreading at maturity, more or less flat, single mid-veined and 2-4 secondary veined on each side of midvein; veins inconspicuous; surface and margins scabrous to scaberulous.

Reproductive morphology: Plant monoecious; culm generally 60 to 100 cm long, in robust form reaching up to 90 to 95 cm; in shortest/miniature form 20 to 40 cm long; flowering nodes 7-15 per module; sheath of upper foliages concealing nearly or almost whole culm; leaves never overtopping the inflorescence; lower 5-7 bracts just like foliage leaves, well short to inflorescence top in robust form to hardly equaling the inflorescence top in shortest form; lowest bract longest, 17 to 33 cm long in robust form and 3 to 5.5 mm wide at middle; surface scabrous; bract-sheath distinct like other foliages; lowest one longest, to 3.5 cm long in robust form.
persistent, covering the whole culm; lower half of bract reddish, upper half reddish brown; upper bracts gradually decreasing in length and breadth. Inflorescence longer with 4-14 flowering nodes; 15 to 65 cm long in robust form, narrow, fascicled, sometimes pendulous; peduncles 1-7 per node within each sheath; spikes 5-15 per node; peduncles unequal, unbranched or branched; longest peduncle 2.5 to 4.5 cm long excluding ensheathing part; individual spike 2.5 to 7 cm long, linear, lax, olive-green to dark-green, predominantly female flowered on lower shorter spikes of lower nodes; spikes on the upper nodes gradually longer; longer spikes always on longest 3-4 peduncles of each and every flowering nodes; spikes androgynous, 5.5 to 7 cm long; maleness increased with the increase of length of the inflorescence and peduncles; topmost 2-3 spikes per module totally male; flowering glumes 20-100 per spike; glumes distantly placed; sterile glumes 10-15 at the middle and at the top of the spikes originated from middle and upper part of the inflorescence; sometimes 2-3 spikes per module or per node may become totally sterile; most of the spikes female, lax, linear, 1.5 to 5.5 cm long, 20 to 80-flowered. Female spikes or pistillate portion of the androgynous spikes distinct, 2 to 5.5 cm long; 15 to 70-flowered; female glumes comparatively shorter than utricles, 2.5 to 3 mm long, loosely arranged; ovate to ovate-lanceolate, obtuse, cuspidate; cuspida 0.7 to 1 mm long; generally single-veined, rarely with two additional incomplete veins, one on each side of the midrib; both tips and margins hyaline, coriaceous; stalar base bulbous, gradually tapered at apex; stigmas 3. irregularly projected. Staminate portion in androgynous spikes inconspicuous, very short, 2 to 5-flowered in basal few nodes, comparatively longer in the middle nodes and in the upper nodes, up to 55-flowered in the middle and upper androgynous spikes; in male spikes conspicuous, topmost in position generally and also 2-3 spikes in each and every node on longest peduncles, comparatively longer, 5.5 to 7 cm long, 55 to 90-flowered on longest peduncle; male glumes smaller, 2.8 to 3.7 mm long, much overtopped, pale light brown; in all cases spike axes very delicate; stamens 3; filaments comparatively longer, 2 to 2.5 mm; anthers shorter, linear to linear-oblong, 1.5 to 2 mm, slightly appendiculate, without any projections; sterile glumes alike to fertile female glumes. Utricles trigonous, 3.5 to 4.2 mm long, slightly stipitate; stalk 0.5 to 0.9 mm, loosely attached with the axis; veins inconspicuous, hispid, and scabrous on angles of beak, sometimes upper half of utricles hispidulous; beak deflexed, 1 to 1.5 mm long, conic-linear, distinctly bidentate, dark green; faces of utricles with more than two prominent ribs. Nuts ovoid.
2 to 2.5 mm x 1 to 1.25 mm, triangular in cross section, closely filling the utricle, narrowed at base.

**Microcharacters (SEM study):** Utricle cells of intercostal region not clear, inconspicuous, appeared as rectangular to polygonal in outline; outer walls of intercostal region sometimes raised and sometimes depressed; costal cells comparatively longer than intercostals cells. Nuts with cellular appearance; cells of the middle part of nut penta- to hexa-gonal; cells of distal half rectangular to penta-gonal; cells more or less isodiametric, each one with single distinct central silica body; silica more distinct towards proximal and middle portion; cells of basal region elongated, tetra- to penta-gonal, sometimes devoid of any silica body; basal platform of the silica body distinctly concave, without any ornamentation; central body slightly to moderately raised, conical with pointed apex, devoid of satellite body; periclinal wall indistinct; cells of stylopodium pentagonal, isodiametric, with raised outer walls, devoid of silica body.

**Anatomy**

Culm: Triangular in transverse section, one corner rounded and two corners obtuse; Epidermis: slightly wavy or undulate, with papillate cells. Specimens examined about 5 mm in length. Translucent ground tissues towards the centre, spongy in nature and devoid of air-cavity in the ground tissue; cells of ground tissue rounded to polygonal in shape and larger in size. Air-cavities in the peripheral region only, arranged between the vascular bundles, oval to rectangular in outline; cells within the air cavities transversely oblong. Assimilatory tissues: as chlorenchyma cells present in peripheral region; cells rounded and slightly smaller than the cells of ground tissues. Vascular bundles: many, scattered within chlorenchyma tissue and in ground tissue; densely placed in peripheral region but few towards the center; vascular bundles more than 150, arranged somewhat in 3-4 rings and often indistinct; bundles round to oval in shape; minor vascular bundles always rounded; vascular bundles always with 2-3 conspicuous metaxylems. Sclerenchyma tissue: on both sides of the vascular bundles and in 2-3 layers but not forming girder; sclerenchymatous cells arranged in patches on the peripheral region not forming a girder of vascular bundles; sclerenchyma cells of central vascular bundle present on both the sides of vascular bundle; peripheral girder V shaped and connected with the epidermal layer.
vascular bundles with the sclerenchyma tissue forming 2-4 layers surrounding the vascular bundle; minor vascular bundle with single-layered sclerenchyma cells.

Leaf: Lamina widely V-shaped to somewhat flattened in cross section, dorsiventral; keel slightly protruding and slightly rounded tip; lamina of somewhat uniform thickness but gradually narrowed towards margins; tip of the margins sub-acute; studied specimens 0.9 to 1 cm long. Epidermis: adaxial epidermal cells quite larger than the abaxial cells; cells oblong to barrel-shaped and of different sizes in both the epidermal layers; cells resting upon the sclerenchymatous layer smaller than the adjacent cells; adaxial cells in the hinge portion largest of all, 16-18 in number, out of hinge cells, middle 2-3 cells comparatively smaller than other cells; cuticles on both the surfaces; adaxial epidermal layer thickly cuticularized than lower than abaxial surface. Mesophyll: of chlorenchyma cells well developed; layers of chlorenchyma interrupted by air cavities and the vascular bundles; cells well developed around the air cavities. Sclerenchymatous cells: associated with the vascular bundles present on both sides of vascular bundles; in the major vascular bundles forming a sclerenchyma girder; shape of the girder ranges from abaxial securiform and adaxial cap in hinge vascular bundle, abaxial turbiniform and adaxial baculiform in keel/median vascular bundle; girder of keel portion extended up to epidermal layer; the abaxial girder extended up to the abaxial epidermal layer in case of hinge vascular bundle only; separate and distinct patch of sclerenchyma attached with the adaxial epidermal layer present near the margins and not connected with any of the major or minor vascular bundles. Vascular bundles: arranged in single row, 7-9 in number in each half of the lamina, equidistant from both adaxial and abaxial epidermal layers, oval to rounded in shape; the major and the minor vascular bundles arranged alternately; all vascular bundles with 2 conspicuous metaxylems; major vascular bundles near to the abaxial epidermis and minor at the equidistant from two epidermal layers; bundle sheath single-layered with sclerenchymatous cells. Air cavities: small, oblong to rectangular in outline; cells within translucent, thin-walled, nearly square to rounded or oval-shaped, cavities surrounded by chlorenchyma cells.
Fig. 112. Habit and inflorescence of *Carex insignis*

A. Habit (lower); B. Habit (terminal); C. Inflorescence (Diagrammatic representation of arrangement of flowers on spikes).

- Male flower.
- Female flower.
- Sterile flower.
Plate LV. Photographs of habit and inflorescence of *Carex insignis*

Fig. 113. Morphology of female glumes, utricles, nut and male glumes of *Carex insignis*

A. Sterile glume; B-F. Female glumes (from base towards apex); G. Utricle with style and stigma; H. Mature utricle; I. Nut; J and K. Male glumes.
Plate LVI. Scanning electron microphotographs of utricle and nut of *Carex insignis*

Fig. 114. Anatomical features of culm of *Carex insignis*
A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 115. Anatomical features of leaf of *Carex insignis*

A. T. S. of lamina (diagrammatic); B. Laminar groove (cellular); C. Laminar lateral portion (cellular); D. Laminar edge (cellular).
Plate LVII. Microphotographs of anatomical features of culm and leaf of Carex insignis

1. T. S. of culm; 2-3. Culm-portion magnified; 4. T. S. of lamina (laminar groove region); 5. Laminar lateral portion; 6. Laminar edge. Scale bar- 1 (300μm); 2 and 3 (200μm); 4. 5 and 6(50μm).

This section of Carex is characterized as follows:

Involucral bracts leafly, persisting with long sheaths. Spikes usually having bisexual floral combination, rarely only unisexual, cylindric or oblong, densely or subdensely many-flowered, rarely loosely flowered, single in an involucral bract sheath, rarely ramose and arranged in a panicle. Female glumes lanceolate-ovate or ovate, rarely oblong; stylar base not thickened; stigmas 3. Utricles ellipsoid or obovoid-ellipsoid, rarely narrowly ovoid, obtusely trigonous or slightly inflated trigonous, inconspicuously veined, or rarely distinct, with rather long or slightly long beak; orifice 2-toothed or emarginate. Nuts subloosely enveloped.


Description (Figs. 116-120; Pls. LVIII-LX)

Morphology

Vegetative morphology: Perennial herb, usually 28 to 45 cm long; caespitose, modules 2-7 per plant; phyllopidic, loosely tufted. Roots light brown dark-brown, rarely tomentose. Underground stem stoloniferous; stolons stout, hard, elongated, deep brown horizontal; upright stems ensheathed with leaf-bases as well as by bladeless leaf-sheath; bases of the leaf-sheath pale brown, ribbed, dull, never breaking down into any kind of fibres; leafless sheath short, 2-5, reddish brown when immature, pale brown at maturity; bases of leaf-sheath and bladeless sheath together form a conspicuous build up at the base of aerial stems. Leaves mostly in elongate rosettes, commonly in several groups; leaves 5-11 in each group, just equaling to or slightly exceeding inflorescence top, mostly existing for single season; leaf-blades 25 to 40 cm long and 5 to 11 mm wide, surface and margins scabrous, W-shaped in cross section or sometimes flattened, single mid-veined; secondaries indistinct.
Reproductive morphology: Plant monoecious. Culms 23 to 31 cm long, stout, acutely trigonous, just equaling to or slightly shorter than the leaf length; flowering nodes 3-6 per module; sheath of bracts and foliages partially covering the culms; lower 3-5 bracts leafy, equaling to or slightly overtopping the inflorescence top; lowest one longest, 25 to 30 cm long and 6 to 9 mm wide; bract-sheath slightly inflated, distinct as like as other foliages; lowest sheath longest, 1.5 to 3.2 cm long, persistent; upper bracts and sheath gradually decreasing in length and blade of bracts also decreasing in breadth in the upper side. Inflorescence elongate-oblong, dense, fascicled, to 30 cm long; peduncles 2-7, slender; spikes generally 2-12 per node, rarely spikes 15-17 when secondary peduncles developed; peduncles unequal in length, longest one to 11.5 cm long; lowest flowering node with least number of peduncles; number gradually increases at upper side; peduncles erect, not drooping even at maturity, bearing a single spike, or sometimes again secondary peduncles having 4-10 spikes; lowest flowering node distant, 9 to 10.5 cm widest from second one; individual spike always peduncled, even the secondary spikes with comparatively shorter stalk, medium sized and 0.5 mm to 3 cm long; spikes of secondary peduncles shorter, oblong-cylindric to narrowly ellipsoid when mature; all spikes androgynous, primarily female; flowering glumes 25-70; male section always in close set while female section spreading to ascending, creamish brown to straw-coloured. Pistillate portion basal, conspicuous, 0.5 to 18 mm long, upto 55-flowered; female glumes slightly longer than utricle, 4 to 4.5 mm long, ovate-elliptic, acute, hyaline to brightly straw-colored; midrib greenish; 1-3-veined; style comparatively shorter, base not dilated; stigma 3, longer, curved, having strongly projected glochidiate surface. Staminate portion always terminal, comparatively shorter, 3.5 to 9 mm long; 10-12-flowered, straw-colored, elliptic when matured; male glumes linear-lanceolate-elliptic, acute, comparatively longer, 6 to 6.5 mm long, single mid-veined, glabrous; stamens 3, equal; filaments comparatively shorter, to 1 mm long; anthers linear-oblong; anther crests appendiculate, bluntly muticuous. 2 to 2.5 mm long. Utricles narrowly ovoid-ellipsoid, trigonous, spreading at maturity, loosely attached, 3.5 to 4 mm long; veins indistinct, gradually narrowed into comparatively longer beak, glabrous throughout, occasionally scabrous or hispidulous along the ridges, olive-green, finally black, not inflated; beak 1.5 to 2 mm long, glabrous, deeply bidentate; aperture oblique. Nuts ellipsoid, trigonous, triangular in cross section, dark-brown, slightly stipitate.
**Microcharacters (SEM study):** Utricle: Intercostal cells of proximal half asymmetric, rectangular, outer walls concave; cells of distal 1/3rd of utricle rectangular, some of them vertically elongated, some of them horizontal and more congested towards apex; outer walls of all cells concave; cells of the stylopodium rectangular. Nuts: cells of surface isodiametric to heterodiametric, with single, central, conical silica body; basal platform of silica distinctly concave, ornamented; central body of silica distinctly raised with blunt apex; devoid of secondary silica body and satellite; central body radiated with 3-6 distinct bars; cells of stalk portion sometimes elongated, or sometimes polygonal; elongated cells devoid of silica body; central body of silica not of same size; longest one 8-10 times longer than the smallest one; height of silica bodies also variable; apex sometimes blunt ended, or sometimes acute.

**Anatomy**

Culm: In transverse section triangular, with rounded corners; corners without any distinct sclerenchymatous patches. Epidermis: single cell-layered thick; cells barrel-shaped, with very thick cuticle; epidermal papillae and prickles absent. Spongy ground tissue towards the centre, translucent. Air-cavity: absent, but aerenchyma found in ground tissue, present at the peripheral region, on the innerside of the chlorenchyma; rectangular to oval in outline, alternately arranged with major and minor vascular bundles, covered with aerenchyma tissue; cells of aerenchyma variable, polygonal, rectangular to oval in shape, comparatively longer than the surrounding cells. Assimilatory tissue: as chlorenchyma forming layers at the peripheral region of culm, interrupted by air cavities/ air chambers and the vascular bundles; 5-9 cell-layered; air cavities and vascular bundles surrounded by the chlorenchyma tissue layers, 3-5 cell-layered to the peripheral region and 1-3 cell-layered towards central region. Vascular bundles: in two complete rows and one incomplete row; vascular bundles 48-55 in outer row, 50% of which major, remaining attached with the sclerenchyma girder; rest 50% minor, devoid of any sclerenchyma girders; vascular bundles 30-35 in second row; vascular bundles 12-15 in third row (incomplete); all larger; central ground tissue massive, without any vascular bundles; major and minor vascular bundles in alternating fashion; major bundles of periphery remain embedded in chlorenchyma and partially within the ground tissue whereas primary vascular bundles of the outer layer totally embedded in chlorenchymatous tissue; vascular bundles mostly oval, metaxylems few, 2-3, freely arranged;
both the poles of major vascular bundles sclerified, in the form of sclerenchyma girders on the peripheral side, extending up to epidermis; minor vascular bundles surrounded by 1-3 sclerotic cell-layers. Sclerenchyma tissue: generally associated with major and minor vascular bundles, also remain in separate patches, oval-triangular, remaining attached with epidermis, opposite to major vascular bundles, rarely with the minor one; in major peripheral vascular bundles outer sclerenchyma girders T-shaped to baculiform and inner girders crescentiform; all the major and minor vascular bundles except the peripheral major vascular bundles remain surrounded by 1-3 layers of sclerotic tissue. Ground tissue: central massive, devoid of air-cavities and vascular bundles; cells polygonal, comparatively longer than the peripheral chlorenchyma cells; ground tissue cells of peripheral region comparatively smaller.

Leaf: Lamina in transverse section inversely W-shaped, sometimes flat, margins revolute, dorsiventral; keel rounded, prominent, protruding towards the abaxial side, forming a prominent ridge on abaxial and furrow on the adaxial surface, not terminated by any silica body; lamina thickest between the median portion and margins and gradually tapering towards margins; margins rounded. Specimens examined 0.5 cm to 1 cm long. Epidermis: adaxial epidermal cells larger than the abaxial one, assymetrical in size and shape, with prominent bulliform cells; adaxial cells at the attachment point of sclerenchyma girders quite smaller, more or less barrel-shaped; cells larger at the hinge region; hinge made up of 10-11, single-layered palisade like fleshy cells; palisade parenchyma absent; abaxial epidermal layer more or less uniform, made up of barrel-shaped cells; 30%-50% of the abaxial epidermal cells adorned with papillate extension, papillate epidermal cells more prominent in the intermediate position between keel and margins. Sclerenchyma tissue: always associated with vascular bundles; in hinge region sclerenchyma forms a girder on the abaxial side, remain connected with the abaxial epidermal layer; girder less capped or crescentiform; on adaxial side 1-2 cell-layered thick to form a cap like structure on vascular bundle, not extended up to the adaxial epidermal layer; major vascular bundles intermediate between the middle keel portion and the margins connected with massive sclerenchyma girder on both adaxial and abaxial sides; adaxial girder more massive, T-shaped to baculiform, 11-13 cell-layered thick; abaxial girder crescentiform, 2-3 cell-layered; minor vascular bundles surrounded by 1-2 cell-layered sclerenchyma tissue, totally devoid of sclerenchyma girders; at the margins, just opposite to the last vascular bundle, 3-4 cell-layered
thick, 15-20-celled, single patch of sclerenchyma also present, may or may not be associated with
the vascular bundles. Mesophyll tissue: homogenous mass, chlorenchymatous, not differentiated
into palisade and spongy parenchyma; extending from adaxial epidermis to abaxial epidermis.
interrupted by aerenchyma of air cavities and vascular bundles on regular basis; mesophyll cells
more or less isodiametric, oval, barrel-shaped or rectangular. Air cavities: occurred in alternate
fashion between vascular bundles; rectangular–nearly rectangular in outline; aerenchyma cells
rectangular to rhomboidal, sometimes in the form of cavity, surrounded by the chlorenchymatous
cells or tissue. Vascular bundles: 13-17 in each side or half of the lamina; all abaxial, always in
single row; half of them major and other half minor; major and minor vascular bundles arranged
alternaty, equidistant from the epidermal layers as well as vascular bundle to vascular bundle: all
oval in shape, 2-5 metaxylems placed in 2-3 directions, larger metaxylems generally singly
arranged; massive sclerenchyma girders on each side of the major vascular bundles, extending up
to both adaxial and abaxial epidermis; in minor vascular bundles just surrounding without any
girders. Bundle sheath double-layered, outer sclerenchymatous and inner parenchymatous.
Bulliform cells present only in the adaxial epidermis, bulged, comparatively larger, not papillate.
Fig. 116. Habit and inflorescence of *Carex polycephala*

A. Habit; B. Inflorescence (diagrammatic); C. Arrangement of flowers on spike (Diagrammatic).

[Diagram showing habit and inflorescence of Carex polycephala]

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Male flower, Female flower, Sterile flower
Plate LVIII. Photographs of habit and inflorescence of Carex polycephala

1. Habit; 2. Inflorescence (a part).
Fig. 117. Morphology of female glumes, female flower, gynoecium and utricle of *Carex polycephala*

A. and B., Female glumes; c. Gynoecium with utricle; D. Utricle; E. Stigmatic surface (magnified).
Fig. 118. Morphology of nut, male glumes and stamens of *Carex polycephala*

A. Nut; B. T.S. of nut; C-E. Male glumes; F. Stamens
Plate LIX. Scanning electron microphotographs of nut and utricle of Carex polycephala

Fig. 119. Anatomical features of culm of *Carex polycephala*

A. T. S. of culm (diagrammatic); B. A portion of culm (cellular).
Fig. 120. Anatomical features of leaf *Carex polycephala*

A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate LX. Microphotographs of anatomical features of culm and leaf of *Carex polycephala*

1-3. Three different corners in T. S. of culm; 4. T. S. of Lamina; 5. Laminar groove; 6. Laminar lateral portion. Scale bar-1, 2, 4 5(300µm); 3 and 6(200µm); 5 (250µm).

This section *Debiles* (J. Carey) Ohwi is characterized by the following features:

Spikes unisexual, rarely bisexual; female spikes linear to cylindric, rarely oblong, loosely or very loosely flowered, usually solitary in an involucral bract sheath, spikes 2 or 3 exserted from an involucral bract sheath or disposed in racemose, or in paniculate inflorescences (synflorescence). Female glumes lanceolate-ovate, oblong-ovate, ovate, or oblong. Utricles ellipsoid, oblong-lanceolate, lanceolate, or narrowly oblong, rarely obovoid, obtusely trigonous, inconspicuously veined, rarely laterally 2-veined, base usually stipitate, apex with long beak; orifice obliquely truncate, sometimes emarginate or shortly 2-toothed. Nuts tightly enveloped with utricle; stylar base not thickened; stigmas 3.


**Description**

(Figs. 121-126; Pls. LXI-LXIII)

**Morphology**

**Vegetative morphology:** Perennial herb, stout, 80 to 125 cm long; phyllopodic, caespitose; modules 3-20 per plant, loosely to very densely tufted, occasionally matted. Roots light brown, tomentose. Underground and ground level stems generally bulbous, sometimes creeping with short length, hard, devoid of stolon. Leaves in basal clusters, 7-10; basal 4-5 bladeless, prominent in juvenile module but inconspicuous in mature modules, persisting with leaf-sheath; bases of leaf-sheath initially cream-colored, ultimately chestnut-brown along with bladeless sheath, persistent, not breaking down into any fibrilous structure; older leaf-sheath as 2-3 seasoned old rarely breaking down into fibres; leaves mostly basal, 1-2 in lower part of culm; leaf-blades 40 to 50 cm long and 3 to 7mm wide, gradually tapered to trigonous apex, covering half of the length to nearly equaling to the length of the culm.
Reproductive morphology: Plant monoecious; flowering stem 30 to 70 cm long, trigonous with acute angles, much shorter than the leaf-blades; 3-5 flowering nodes per module: lower 2-3 bracts leafy, nearly reaching or slightly overtopping the inflorescence top; lowest bract longest, 25 to 40 cm long and 2.5 to 3.5 mm wide; bract-sheath distinct; lowest one 2.5 to 4 mm long, covering the base of peduncle, gradually decreasing in length and breadth in upper nodes; bract at the base of top most spike filiform. Inflorescence of 5-6 erect spikes; 40 to 60 cm long, never drooping, even at maturity, always single per node; lower 2-3-peduncled; lowest peduncle longest, 5 to 8.5 cm long; lower two spikes very distantly placed, 35 to 45 cm away from the second peduncle, distance between 2nd and 3rd node 15 to 20 cm, next internodes gradually decreasing in length; topmost 2-3 nodes very congested, nearly antheloid; lower 4-5 spikes totally female; terminal spike always male; spikes linear-oblong to cylindric; terminal male almost concealed amongst the upper female spikes, almost sessile. Female spikes narrowly cylindric to linear-oblong, 5.5 to 7.5 cm long, 70-110-flowered, lax, having erect to sub erect utricles, spreading at maturity; female glumes along with awn/cuspida, much longer than the utricle, variable in length, shape and surface utriculation, 3 to 6 mm long, ovate, very distinctly aristate those near middle of the spike; aristae 2 to 4 mm long; keeled, hyaline or with pale brown markings towards centre; midrib green, slightly excurrent, 1-3-veined; style 0.8 to 1.2 mm long; stylar base of dilated; stigma 3, curved, comparatively shorter, 0.5 to 0.7 mm long, projected. Staminate spikes linear, 4 to 6.5 cm long; flowering glumes 50-75 per spike; glumes narrowly oblong to lanceolate, very distantly placed, 5 to 15 mm long including projection; body of lower glumes much shorter than the awn, 2.5 to 4.5 mm long, awned; length of awn varies, 4.5 to 12 mm, body of upper glumes gradually increasing length and awn length gradually decreasing towards apex of male spike; all glumes 3-veined; midvein very distinct; lateral two inconspicuous; midrib green otherwise hyaline. Utricles slightly swollen, narrowly ellipsoid-ovoid, trigonous, spreading at maturity, 2.7 to 3.5 mm long, glabrous, strongly ribbed; veins 12-14, indistinct; suddenly narrowed into oblong-linear beak; beak as long as body of the utricle or 1/2 of the body of utricles, 0.75 to 1.2 mm long, without any projection; aperture oblique, torned at maturity. Nuts ellipsoid, well filling the utricle, 1.75 to 2.3 mm long, triangular in cross section, sub-stipitate, pale brown.
Microcharacters (SEM study): Utricle not distinguishable with intercostal and costal cells; cells on surface mostly rectangular with distinct periclinal walls. Nut surface: at basal stalk cells rectangular to rhomboidal; devoid of any silica body; cells of upper half polygonal, often indistinct, each cell with single silica body; basal platform plano-concave, ornamentation not clear; central body of silica conical, distinctly raised, apex pointed, devoid of any ornamentation in the basal platform and secondary silica body; satellite and periclinal wall not distinct.

Anatomy

Culm: In transverse section triangular; one corner acute while other two rounded; corners without any sclerenchyma. Epidermis single cell-layered, with thick cuticle. Spongy ground tissue translucent, present towards centre, without any air cavity within the ground tissue. Air cavities: present only at the peripheral region, at the end of the chlorenchyma, almost rectangular in outline, massive, in comparison to other species, alternately arranged with the vascular bundles, filled with translucent aerenchyma; cells of aerenchyma comparatively larger, loosely arranged. Assimilatory tissue: as chlorenchyma forming layers at the peripheral region of the culm, interrupted by the air cavities and the vascular bundles; chlorenchyma cells surrounding by air cavities, 2 to 5 cell-layered thick on the peripheral region and 1-3 cell-layered thick towards centre. Vascular bundles: in two rows; outer row distinct and inner row inconspicuous; other vascular bundles scattered towards the centre; outer row with 30-35 vascular bundles and inner row with 12-15 vascular bundles; others with 5-9 scattered vascular bundles; vascular bundles comparatively dense towards the peripheral region and few towards centre; both minor vascular bundles and major vascular bundles arranged alternately; major vascular bundles of the peripheral region partially embedded in chlorenchyma and partially in ground tissue and minor vascular bundles totally remain embedded in chlorenchymatous tissue; vascular bundles mostly oval; with 3-9 metaxylems in three corners of which 2-4 largest metaxylems always remain freely; others either in groups or singly; diameter of metaxylem largest in respect to other studied species of Carex; both the ends of major vascular bundles having sclerenchyma girders, extending up to the epidermal layer; minor vascular bundles surrounded by 2 to 3 cell-layers of sclerenchyma tissue. Sclerenchyma: always associated with both the major and minor vascular
bundles, rarely remain in separate patches beneath the epidermis and also in the form of girders, securiform to triangular in shape, in the peripheral vascular bundles the peripheral sclerenchyma girders baculiform while the central girders crescentiform; inner vascular bundles of ground tissue surrounded by 2 to 3 cell-layers sclerenchyma, almost crescentiform. Ground tissue devoid of any vascular bundles; cells of the central region polygonal, comparatively larger; cells of peripheral ground tissue comparatively smaller and polygonal.

Leaf: Lamina in transverse section V-shaped; margins slightly spreading; dorsiventral; keel prominent, protruding towards the abaxial side, rounded, forming a prominent ridge on the abaxial side and groove on the adaxial side, devoid of silica body and papilla to terminate the ridge of keel; lamina thickest in between the median vascular bundles and to the margins; submarginal portion sometimes as thick as the median portion, gradually thinner towards the margins and keel region. Specimens examined usually 0.7 to 1.0 cm long. Epidermis: adaxial epidermal cells longer than the abaxial epidermal cells, asymmetrical, quite smaller at the attachment site of the sclerenchymatous patches on adaxial side; adaxial cells largest at the hinge region; hinge made up of 12-14 longest adaxial bulliform cells; abaxial epidermal layer devoid of bulliform cells and papillae or prickle. Sclerenchyma tissue: generally associated with the vascular bundles and also remaining in separate patches on the adaxial side; sclerenchyma never forming a girder on adaxial and abaxial side of the vascular bundles; the amount of sclerenchyma cells comparatively less than the other species of Carex, probably due to amphibian and semiaquatic or marshy habitats. Air cavities: well developed, filled with aerenchyma cells aerenchyma of air cavities occurred between the vascular bundles in alternate manner, rectangular to round in outline, or polygonal-rounded; cells 2-5 times larger than mesophyll cells; largest sized aerenchymatous tissue present in the median portion between the keel region and margins, remain surrounded by chlorenchyma tissue. In hinge/keel region sclerenchyma forming a cap-like structure on both adaxial and abaxial sides, never connected with the epidermal layer and never in the form of girders; abaxial sclerenchyma cap 2-3 cell-layered thick; major vascular bundles at the intermediate position between middle and margins connected with 2-3 cell-layered crescentiform cap of sclerenchyma on the abaxial side and 1-2 cell-layered cap of sclerenchyma on the adaxial side; a patch of oval sclerenchymatous tissue also present opposite to the major vascular bundle of the middle part of the lamina and remain connected with the adaxial
epidermis, separated by 7-8 cell-layered chlorenchyma tissue; minor vascular bundles surrounded by 1-2 cell-layered sclerenchyma as bundle sheath; sometimes 2-3 cell-layered abaxial sclerenchymas also remain associated with the minor vascular bundles; sclerenchyma girders absent with both major and minor vascular bundles. Mesophylls: well developed, chlorenchymatous, devoid of palisade parenchyma, extending from adaxial epidermis to abaxial epidermis, interrupted by massive aerenchyma cells of air cavity as well as vascular bundles; cells isodiametric. Vascular bundles: 12-15 on each half of lamina, arranged in a single row, two types as larger major and smaller minor, arranged alternately, placed at more or less equidistant from epidermal layers, oval to ovoid in shape, with 2-6 metaxylems in triarch, 2-3 always free; diameter of xylem also comparatively larger in this species, largest metaxylem out of the studied species of Carex; others in groups; remain surrounded by sclerenchyma layer and often ill-developed. Bundle sheath in two cell-layered thick, inner sclerenchymatous and outer parenchymatous. Bulliform cells present only on adaxial epidermis.
Fig. 121. *Habit and inflorescence of Carex finitima*

A. Habit (lower portion); B. Inflorescence (portion); C. Inflorescence with arrangement of flowers on spike (dia.

Male flower, Female flower, Sterile flower
Plate LXI. Photographs of habit and ispike of Carex finitima

1. Habit; 2. Female spike (magnified).
Fig. 122. Morphology of female glumes and sterile glume of *Carex finitima*

A. 1\textsuperscript{st} female glume; B. 2\textsuperscript{nd} female glume; C. 3\textsuperscript{rd} female glume; D. 4\textsuperscript{th} female glume; E. 5\textsuperscript{th} female glume; F. Sterile glume; G. 6\textsuperscript{th} female glume.
Fig. 123. Morphology of gynoecium, utricle and nut of *Carex finitima*

A. Mature gynoecium with style and stigma; B. Utricle; C. Nut; D. T.S. of nut.
Fig. 124. Morphology of male glumes of Carex finitima

A. 1st male glume; B. 2nd male glume; C. 3rd male glume; D. 4th male glume; E. and F., Male glumes from middle part of spike.
Plate LXII. Scanning electron microphotographs of utricle and nut of *Carex finitima*

1. Fruit with ruptured utricle; 2. Surface of utricle; 3. Nut; 4. Basal part of nut; 5. Apical part of nut. (sbs-silica bodies)
Fig. 125. Anatomical features of culm of Carex finitima

A. T. S. of culm (diagrammatic); B. A portion of culm (cellular).
Fig. 126. Anatomical features of leaf of *Carex finitima*

A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate LXIII. Microphotographs of anatomical features of culm and leaf of *Carex finitima*

1. T. S. of culm; 2. A portion of culm(magnified); 3. T. S. of lamina; 4. Laminar groove; 5. Laminar lateral part; 6. Laminar edge. Scale bar-1 and 3(300μm); 2, 5 and 6(200μm); 4(50μm).

This section is characterized as follows:
Rhizomes stoloniferous. Involucral bracts not sheathed or shortly sheathed. Spikes usually unisexual; terminal spike always male; lateral spikes female; cylindric, rarely oblong, densely many-flowered. Female glumes ovate or lanceolate-oblong, apex acuminate, mucronate, aristate or muticous; stigmas 3. Utricles yellowish green or stramineous, erect or obliquely patent, ovoid, ellipsoid, or oblong, slightly inflated or inflated-trigonous, many-veined; beak medium sized to long, or rather long orifice shortly 2-toothed, rarely obliquely truncate or emarginate. Nuts rather loosely enveloped.


Description (Figs. 127-132; Pls. LXIV-LXVI)

Morphology

Vegetative morphology: Annual or perennial herb, 30 to 65 cm long, monoecious, phyllopodic, caespitose; modules 2-7 per plant, loosely tufted, spreading. Roots pale brown, tomentose. Stems of both ground level and underground horizontal, stoloniferous, 10 to 20 cm long; covered with creamish ribbed scales. Leaves in subbasal tuft of 5-11, crosses hardly half of the length of culm; lower 2-3 leaves scaly, bladeless, gradually increasing length; bases of leaf-sheath cream-coloured, not persistent, margins splitting into fibres; fibres comparatively longer; forming a conspicuous build up at the base of plant; blades slightly more than half of culm, 20 to 35 cm long and 3 to 6.5 mm wide, straight, linear, flat, with single midvein and 3-4 lateral parallel veins on each side of midvein.

Reproductive morphology: Plant monoecious; culm 30 to 50 cm long, acute triangular in cross section, longer than leaves; flowering nodes 3-6 per module; leaves 5-10 clustered at the
base of culm; lower bracts 1-3, leafy, slight to moderately exceeding or overtopping the inflorescence top; lowest one longest, 10 to 15 cm long and 4 to 6 mm wide, basal in position to spikes, never sheathing, persistent; bracts in upper nodes gradually decreasing in length and breadth; cladophyll totally absent. Inflorescence 7 to 14 cm long of 4-8 erect to slightly drooping lower 1-3 spikes; spikes generally single per node, sometimes more than one spike from terminal node; lowest node distantly placed, 5 to 7 cm away from second node; internodal length gradually decreasing; last two nodes very congested; lowest spike with longest peduncle, 3.5 to 5.5 cm long; length of peduncle also gradually decreasing; terminal spike(s) generally male and basal 3-5 female, sometimes 2-3 male flowers at top and androgynous; terminal spike almost concealed among the female spikes or the androgynous spikes, almost sessile. Pistillate portion of spikes narrowly cylindric, 4 to 5.5 cm long, 120-150-flowered; female glumes much shorter than utricles, 2.5 to 3.5 mm long, ovate, glumes of lower part of spike aristate; glumes from middle and upper part of spike apiculate or slightly mucronate; apex variable as apiculate, mucronate, cuspidate and even aristate, rarely bristled and bi-cuspidate; when aristate length of arista 0.7 to 1.25 mm long; distinctly 1 to 3-veined; sometimes 1-2 branched to unbranched veins present on each side of midvein; female glumes hyaline except the greenish midvein; stylar base slightly dilated, 0.7 to 1.2 mm long; stigma 3, as long as style, irregularly projected. Staminate portion of androgynous spike very short, 2 to 4 mm long, with 15-25 flowering glumes, inconspicuous; male spike terminal, 3 to 5.5 cm long, 110 to 210-flowered, variable in sexuality; after observing more than 30 samples from different localities three different patterns of arrangement found: i) 20-30 basal male flowers and 50-60 male flowers at top and middle portion totally occupied by female flowers; ii) basal 50% of spike represented by 40-50 female flowers and upper portion represented by male flowers and iii) the whole spike covered by male flowers only. Male glumes in close set, not spreading, persistent; size and shape variable, 1st male glume 8 to 9 mm long and awned; 2nd male glume 6 to 6.5 mm long and aristate; length of processes gradually decreases and ultimately become mucronate with scabrid tip; oblong–ovate to lanceolate-oblanceolate. 3.5 to 4.5 mm long, generally single-veined, hyaline with green midrib; stamens 3; filaments short. 0.7 to 0.8 mm long; anthers comparatively longer, oblong to linear-oblong, 3 to 3.5 mm long: crests apiculate. Utricles narrowly ellipsoid-ovoid, trigonous, 3.7 to 4.2 mm long, loosely arranged with axis, spreading at maturity, 4-5-veined, obliquely ascending, glabrous, strongly ribbed.
colored, gradually constricted into a beak; beak 0.75 to 1.5 mm long, minutely serrete; aperture weakly bidentate, hyaline, often reflexed; sometimes upper portion of beak scabrous. Nuts ellipsoid-obovoid, 1.5 to 2 mm long, triangular in cross section, hardly filling the lower half of utricle.

**Microcharacters (SEM study):** Utricle: Intercostal cells at the middle portion rounded to polygonal, isodiametric, outer wall convex; costal cells rectangular, more elongated, comparatively thin-walled. Nut surface with polygonal, isodiametric cells at the basal part, rarely with single silica body per cell; basal platform appeared to be concave; central body raised, apex pointed, without satellite, ornamentation of basal platform, and periclinal wall present.

**Anatomy**

Culm: Triangular in cross section; corners acute, margins wavy and concave, sometimes deeply notched. Ground tissue towards the centre, massive, totally devoid of vascular bundles; cells of ground tissue rounded to polygonal, and devoid of air cavity. Air cavities: present along the peripheral region, oblong to rounded in outline with airenchyma cell; cells rounded to oval or square in shape; cavities well surrounded by the chlorenchyma cells; Assimilatory cells: as chlorenchyma well developed in the peripheral region, 10-12 cell-layered, interrupted by the air cavities and the vascular bundles; cells rounded to oval in shape. Vascular bundles: in a single distinct ring and rarely 2-3 along the periphery, 12-45, both major and minor, alternately arranged, oval in shape, with sclerenchyma cell on both the ends; major vascular bundle with a sclerenchyma girder, baculiform in shape and the central axis deeply crescentiform; minor vascular bundles surrounded by layers of sclerenchyma cells; all having 2-3 large metaxylems arranged in triangular fashion, all embedded by chlorenchyma layer. Sclerenchyma cells: associated with vascular bundles; adaxial girder extending upto chlorenchyma cells, well developed in peripheral region, 10-12 cell-layered thick, interrupted by the air cavities and vascular bundles; the corners of the culm highly sclerified; cells rounded to oval in shape. Sclerenchyma cells associated with vascular bundles; adaxial sclerenchyma forms girder and extending up to the epidermal layer, baculiform to cresenteform, 2 to 3 cell-layered sclerenchyma present the tip portion of the acute corner.
Leaf: Lamina flat-W-shaped with flanged margins in outline with prominent protruding keel, acute; lamina tapering towards the margins; keel region rounded, with single row of hinge cells; cells 18, comparatively larger and swollen. Epidermis: adaxial cells larger than the abaxial cells, over the sclerenchyma strand the cells quite smaller in both the layers. Sclerenchyma tissue: associated with the vascular bundles, sclerenchyma of hinge portion forming girder on both sides of vascular bundles; abaxial girder horizontal, crescentiform and adaxial cap of 2-4 cell-layered thick; the girder of other vascular bundle pulviniform on abaxial side and triangular form on adaxial side; sometimes sclerenchymatous patch not associated with the major vascular bundles: in the minor vascular bundle of tip portion the sclerenchyma surrounds the vascular bundles; a patch of 2-3 layer of sclerenchyma present at the adaxial part of the marginal portion of lamina: long rounded in shape. Messophyll tissue: well developed, interrupted by the presence of air cavities and vascular bundles. Air-cavities: long, oblong, with aerenchyma cells within. Vascular bundles: in single row, 15-17 in one half of the lamina; oval in shape, with sclerenchyma strands on both sides of vascular bundles, with 2-6 large metaxylems. Bundle sheath cell double-layered, outer parenchymatous and inner sclerenchymatous, some interrupted by sclerenchyma cell; in case of smaller vascular bundles sclerenchyma forming complete circle, encircling vascular bundles. Bulliform cells: present in adaxial side, larger in size in groove region.
Fig. 127. Habit and inflorescence of *Carex alopecuroides*

A. Habit; B. Inflorescence (diagrammatic representation) with arrangement of flowers; C. Variation of arrangements of flower in terminal spike (diagrammatic).

- Male flower
- Female flower
- Sterile flower
Plate LXIV. Photographs of habit and inflorescence of *Carex alopecuroides*
Fig. 128. Morphology of female glumes of *Carex alopecuroides*

A, B, C, and D., Fertile female glumes from basal part of spike; E, F, and G., Fertile female glumes from middle part of spike; H. Fertile female glume from top portion of spike.
Fig. 129. Morphology of utricle, female flower of *Carex alopecuroides*

A. Utricle; B. Utricle splitted open; C. Nut (with persistent style and stigma); D. T.S. of nut.
Fig. 130. Morphology of male glumes and stamens of *Carex alopecuroides*

A. 1st male glume; B. 2nd male glume; C. 3rd male glume; D. 4th male glume; E. 5th male glume; F, G, H. Male glumes from middle part of the spike; I. Male glume from top portion of spike; J. Stamens.
Plate LXV. Scanning electron microphotographs of utricle and nut of *Carex alopecuroides*

Fig. 131. Anatomical features of culm of *Carex alopecuroides*

A. T. S. of culm (diagrammatic); B. A portion of culm (cellular).
Fig. 132. Anatomical features of leaf of *Carex alopecuroides*

A. T. S. of lamina (diagrammatic); B. Laminar groove (cellular); C. Laminar lateral portion (cellular); D. Laminar edge (cellular).
Plate LXVI. Microphotographs of anatomical features of culm and leaf of *Carex alopecuroides*

1. T. S. of culm; 2. A portion of culm (magnified); 3 and 4. T. S. of lamina; 5. Lateral portion of lamina. Scale bar-1 and 3(300µm); 2 and 4(200µm); 5(50µm).
Carex subsect. Forficulae Franchet ex Kükenthal in Engler, Pflanzenr. 38. IV. 20: 334. 1909 [“Forficulae”].

This section is characterized by the following features:
Rhizomes often stoloniferous. Culms trigonous, clothed at base with bladeless sheaths; sheaths more or less disintegrating into reticulate fibers. Leaves flat, with revolute margins. Involucral bracts leafy, sheathless. Spikes 3–6; upper 1 or 2 spikes male; remaining spikes female, cylindric, densely many-flowered; upper one approximate, sessile; lowest spike distant from next, with erect short peduncle. Female glumes brown or pale, mucronate or not. Utricles membranous, plano-convex or biconvex, veinless or obscurely veined, beaked.


Description (Figs. 133-139; Pls.LXVII-LXX)

Morphology

Vegetative morphology: Perennial herb, 50-90 cm high, phyllopodic, caespitose: modules commonly with 2-5 per plant, rarely up to 7; monoecious. Stem triangular (broadly), with acute, winged angles, solid. Aerial stems erect, loosely tufted. Roots reddish brown. Ground level or under-ground stems not developed horizontally or vertically; stems rhizomatous; rhizomes bulbous; aerial stems erect, acute triangular in cross section; Leaves in basal tufts of 10-12, existing for a single season, never exceeding the culm or the inflorescence top; hardly reaching or extended up to 2/3rd of the aerial stem; lower 5-7 leaves bladeless, scaly to gradually increasing in length and gradually passing upwards; intermingles into foliage leaves; foliage straight, not curved or recurved; leaf-sheath persisting, rarely breaking down into deep brown fibres; mouth of leaf-sheath breaking down into reticulate fibres; forming a conspicuous build up at the base of the stem, reddish brown– cinnamon–purplish coloured; leaf-blades 20 to 45 cm long and 7 to 9.5 mm wide, straight, linear, folded as W- shaped in cross section; lower few along
Reproductive morphology: Plant monoecious. Culm 50 to 90 cm or rare often to 100 cm long, triangular in cross section with winged angles; angles acute; much longer than foliage leaves; flowering nodes 2-5 per module. Leaves 10-12 clustered at the base of culm to 3-5 basal nodes, absent on upper half of the stem; lower bracts leafy; upper filiform, basal in position to inflorescence, gradually decreasing in length and breadth; lower 2-3 bracts alike to leaf-blades, equaling to or slightly exceeding inflorescence top, 10 to 20 cm long and 6 to 7 mm wide at middle; surface scaberulous; bract-sheath absent, flapping to scarcely sheathing, persistent; in upper nodes gradually decreasing in length and breadth, ascending; cladophyll absent. Inflorescence 12 to 20 cm long, of 4-9 erect, overtopping spikes; spikes single per node, rarely 2-3 on top; terminal spike(s) sessile, lower on slender, erect peduncles; lowest peduncle 8 to 12 mm long, gradually decreasing in length or ascending; terminal spike(s) male, gynaecandrous, or with female flowers at middle part, or variable in sexuality; terminal one 4 to 8.5 cm long (excluding peduncle); lower 3-8 spikes female, 4.2 to 10 cm long (excluding peduncle); terminal spike(s) variable in sexuality. Different combinations of arrangement of flowering glumes of different sexuality present as seen after studying more than 50 individual samples of in-situ population, collected from different localities (Fig. 134). These are as follows:

i) terminal spike with the admixture of male and female flowers; male at the base and female at the top; middle portion with the mixture of both male and female flowers; ii) terminal spike totally male, however, sometimes shorter spike of 1.5 to 2.5 cm also present at the base of terminal male spike; iii) terminal spike with basal 20-25 sterile glumes and the upper or top portion with fertile male and female flowers, middle portion with the admixture of both male and female flowers; iv) basal portion with 15-20 male flowers, upper portion with 15-20 female flowers and the middle portion with groups of both 15-20 male and female flowers; v) both basal and top portion with 30-40 male flowers in group and the middle portion with mixture of both male and female flowers; and lastly vi) admixture of both male and female flowers throughout the spike. Lower spikes distantly placed, lowest often 3 to 4.5 cm wider; gradually becoming congested; each spike distinct, divergent to drooping, linear to cylindrical in outline. Staminate
spikes variable; 4 to 8.5 cm long, many, generally 200-220-glumes per spike; basal 4-5 glumes distant, or sometimes 20-25 sterile glumes at basal portion; upper glumes in very close set; slightly spreading at maturity, persistent; male glumes ovate-elliptic to ovate-lanceolate, 4.5 to 7 mm long; 1st one rarely 2-veined, 2nd one 3-veined, awned-aristate; arista scabrid, upto 3 mm long, sometimes truncate, or sometimes two half asymmetrical; margins winged, purple-colored; middle portion hyaline to light green; stamens 3. Pistillate spikes 4.2 to 10.5 cm long, many, generally 200-250-flowered; glumes shorter or hardly equaling to the utricles; body of glumes covering half of the utricles, 3 to 3.5 mm long; ovate-obovate, margins truncate and/or emerginate, apex distinctly awned or aristate; arista 1 to 1.5 mm; distinctly 3-veined; margins winged, purple-coloured; midvein region hyaline-light green, glabrous; style short, 1 to 1.5 mm long; stigma 2, comparatively shorter to 1 mm long; surface with irregular projections. Utricles ellipsoid to ovoid, compressed, biconvex to flat, 3 to 3.5 mm long, loosely arranged with axis, spreading at maturity, more or less veinless, sometimes 3-5-veined and inconspicuous, and purplish gland at base and apex, glabrous; beak very short, 0.2 to 0.3 mm, triangular, with hardly any projection, not bidentate; olive green–purplish green; aperture transverse. Nuts biconvex, 1.5 to 2.2 mm, hardly covering 2/3rd of utricles.

**Microcharacters (SEM study):** Utricle: Intercostal cells rounded, rectangular and sometimes polygonal; outer wall plano-concave; cells more or less isodiametric; costal region 2-3 cell-layered; cells much more elongated, thin-walled. Nuts surface cellular; cells polygonal, mostly hexagonal at middle, elongated on distal and proximal part; single silica body per cell; central body of silica more rounded, distinctly raised; basal body plano-concave; absence of satellite body, ornamentation of basal body and radiating bar observed; periclinal walls distinct, persistent and linear at the middle of nuts.

**Anatomy**

Culm: Acute-triangular; magins slightly concave with acute corners in transverse section; specimens examined generally 0.8 to 1 cm long. Translucent ground tissue towards the center, spongy in nature and devoid of air cavities in the ground tissue. Almost all the epidermal cells adnored with papillae or prickle. Ground tissue: cells somewhat rounded in shape and larger in size. Air-cavities: comparatively larger, in the periphery region, alternate with the vascular
bundles; outline of the air chamber rounded to oval; cells within air cavity transversely oblong to rectangular, partially within the chlorenchyma tissue. Assimilatory tissue: as chlorenchyma, arranged in 8-9 cell layers in peripheral region, interrupted by vascular bundles and air cavities; cells rounded to oval in shape, smaller in size in comparison to the cells of ground tissue. Some of the air cavities surrounded by the chlorenchyma tissue. Vascular Bundles: generally 50-55; major bundles 30-32 and minor bundles 18-20, both arranged in two concentric rings; peripheral region densely occupied by vascular bundles, after the periphery an other row of few vascular bundles; major and the minor vascular bundles arranged alternately; vascular bundles oblong in shape; metaxylem 3-6 large, conspicuous; sclerenchyma tissue: present on both the sides of the vascular bundles; first row or the peripheral vascular bundles always with adaxial sclerenchymatous girder and the girder extending to the epidermal layer; sclerenchymatous tissue of 4-7 cell-layered thick in the peripheral major vascular bundle and 3-4 cell-layered in major central vascular bundles; peripheral sclerenchyma forming a girder and baculiform to securiform while the abaxial crescentiform and extending upto epidermal layer; sometimes a distinct oval-triangular sclerenchyma patches present, alternate to major vascular bundles, not associated with any vascular bundles and remain attached with the epidermis.

Leaf: Lamina inversely W-shaped in transverse section; hinge portion widely V-shaped, dorsiventral; keel portion protruding and rounded. Lamina broader at the keel portion and gradually tapering towards the margins; tip of margins rounded. Epidermis: cells of the adaxial surface different from abaxial one; cells barrel-shaped to oblong, various in shape; adaxial cells of the hinge portion conspicuously large enough; abaxial epidermal cells hugely adnored with papillate extension or the epidermal cells papillate. The only species where hinge made up of 3-layers bulliform epidermal cells (1st layer with 19-21, second layer with 25-27 and third layer with more than 30; outer layer with large cells; middle layer with medium-sized cells, innermost layer with smaller cells but alike to the other epidermal cells); adaxial cells much larger than that of the abaxial epidermal cells. Some of the adaxial, epidermal cells bulged to form bulliform cells. Cuticular layer thick in the adaxial portion than that of the abaxial one. Mesophyll tissue: clorenchymatous, well developed around the air cavities; chlorenchyma tissue layer interrupted by the air cavities and vascular bundles; the cells nearly rounded in shape but smaller in comparisons to adaxial epidermal cell. Sclerenchyma tissue: always associated with the vascular bundles.
present on both the sides of the vascular bundles; major vascular bundles form sclerenchymatous
girder extending up to the adaxial and abaxial epidermal layer, sometimes the girders not attached
with the vascular bundles but sclerenchyma girders forming patches, discontinued by
chlorenchyma tissue. In minor vascular bundles, it just surrounds the vascular bundles by 1-2 cell
layers. The hinge girder horizontal and crescentiform (abaxial) and adaxial cap (hinge vascular
bundle); baculiform (adaxial) and crescentiform (abaxial) in keel-vascular bundle. Vascular
bundles arranged in a single row, 15-17 in each half of the lamina, oval in shape with 3-4 large
metaxylems, sclerenchyma cells on both the sides of the vascular bundle; sclerenchyma of hinge
portion forming abaxial girder and sclerenchyma of keel portion forming both adaxial and abaxial
girders. Vascular bundles: equidistant from the epidermal layer to very near to the abaxial
epidermal layer. Air Cavities: long and rectangular in outline; cells translucent, thin-walled,
rectangular to nearly quadrangular in shape, unequal and well surrounded by the chlorenchyma
cells. Bundle sheath 2 cell-layered thick; outer parenchymatous and inner sclerenchymatous and
interrupted by the sclerenchyma cells. Bulliform cells numerous, present at the adaxial epidermal
layer, 3 cell-layered in hinge region and singly or in a single layer in other region of the adaxial
epidermis; number of hinge cells highest in comparison to all the studied species of Carex).
Fig. 133. Habit and inflorescence of *Carex teres*

A. Habit (lower portion); B. Inflorescence.
Fig. 134. Inflorescence of *Carex teres* (all diagrammatic)

A. Inflorescence with arrangement of flowers on female spikes; B1-B6. Arrangement of flowers on terminal spike.

- Male flower, Female flower, Sterile flower
Plate LXVII. Photographs of habit and inflorescence of *Carex teres*
Fig. 135. Morphology of female glumes of Carex teres

A. 1\textsuperscript{st} fertile female glume; B. 2\textsuperscript{nd} female glume; C. 3\textsuperscript{rd} female glume; D. 4\textsuperscript{th} female glume; E. 5\textsuperscript{th} female glume; F. Female glume from middle of spike; G and H. Female glume from top of the spike.
Fig. 136. Morphology of female flower, utricle and nut of *Carex teres*

A. Utricle with stigma; B. Mature utricle; C. Utricle splitted open; D. nut; T.S. of nut.
Fig. 137. Morphology of male glumes of *Carex teres*

A. 1st male glume; B. 2nd male glume; C. 3rd male glume; D. 5th male glume; E. 7th male glume; F, and G., Male glume from middle part of spike; H. Male glume from terminal part of spike.
Plate LXVIII. Scanning electron microphotographs of utricle and nut of *Carex teres*

1. Utricle and nut; 2. Tip of utricle; 3. Base of utricle (magnified); 4. Nut surface (magnified);
5. Apical part of nut; 6. Basal part of nut. (sbs-silica bodies)
Fig. 138. Anatomical features of culm of *Carex teres*

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 139. Anatomical features of leaf of *Carex teres*

A. T. S of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate LXIX. Microphotographs of anatomical features of culm and leaf of *Carex teres*

1. T. S. of culm; 2, 3, and 4., A portion of culm(magnified); 5. T. S. of lamina.
Scale bar-1 and 5(300μm); 2, 3 and 4(200μm).
Plate LXX. Microphotographs of anatomical features of leaf of *Carex teres*

1. T.S. of laminar lateral portion and margin; 2. Laminar groove; 3 and 4. Laminar lateral part (magnified). Scale bar-1 (300μm); 2 and 3 (200μm); 4 (50μm).

The section *Graciles* is characterized by the following features as:

Plants perennial, with short rhizomes, rarely with long, slender rhizomes, without stolon. Involucral bracts sheathed. Spikes few to numerous, single or several fasciculate in an involucral bract-sheath, or arranged as in a raceme or panicle; peduncles slender; usually bisexual, rarely with both unisexual or bisexual and unisexual or bisexual; spikes androgynous, lax or dense many-flowered, rarely few-flowered. Stylar base slightly thickened; stigmas 2, rather long. Utricles lenticular, or plano-convex, several-veined; base stipitate; beaked; orifice shortly 2-toothed. Nuts compressed-lenticular, or plano-convex.


Description (Figs. 140-144; Pls. LXXI-LXXIII)

**Morphology**

**Vegetative morphology:** Perennial herb; 25 to 75 cm high, rarely to 80 cm long, caespitose, phyllopodic; modules 5-10 per plant, sometimes may be more than 25 modules in dense clusters, loosely to densely tufted. Roots light brown to creamish white. Rhizomes very short, 5 to 15 mm long, hard, devoid of stolon or horizontal underground or ground level stem. Upright stems or the culms partially covered with sheath; persisting as long stiff light brown to dark-brown fibres, stripped with light veins after drying, without reticulation of leaf-sheath. Leaves 4-6, mainly in basal tufts, comparatively shorter and narrower, existing for a single season; basal bladeless sheath 1-5 often present, light brown to reddish brown; the whole structure forming a conspicuous build up at the base; blades 1/2-1/3 of the length of culm or rarely reaching up to inflorescence top, measuring to 65 cm long as in robust specimens and 4 to 7 mm wide, light green to olive-green.

**Reproductive morphology:** Plant monoecious; culm 20 to 65 cm long; flowering nodes 5-12 per module in specimens collected from Tiger Hill, Darjeeling and Llyod Botanic Garden. Darjeeling, flowering nodes per module 3-4, very shorter plant, very slender and weaker, broadly
triangular in cross section; angles rounded; blades of bract nearly reaching the top of inflorescence or shortly exceeding the inflorescence top; bracts of both robust form and shortest form hardly reaching the inflorescence top; the medium growth form of plant, collected from Gymkhana, Darjeeling having greatly exceeding bracts and reaching nearly 25 to 30 cm length as overtopping inflorescence; lowest bract of robust plant up to 48 cm long and 3 to 4.5 mm wide; gradually decreasing in length and breadth upwards, ultimately become filiform; bract-sheath comparatively shorter, distinct; lowest one bract-sheath of robust form of plant 4.5 to 5 cm long; gradually decreasing in length on upper part and partially covering the culm. Inflorescence forming spicate structure of 4-11 spikes, in shortest form of plant 3-5 spikes; in robust form with up to 11 spikes; spikes up to 55 cm long; peduncle single per node and each peduncle generally with single spike, sometimes 2-3 spikes on lowest peduncle of which 1 longer and 1-2 basal shorter spikes in arrangement; upper 2-4 spikes sessile, congested; others spikes distantly arranged and generally lowest one 12 to 15 cm apart from second one; upper flowering nodes gradually decreasing in length; peduncles long and the lowest one longest up to 5 cm long excluding sheath, erect, but slightly drooping at maturity, filiform, nodding, glabrous; individual spike 1.5 to 5.5, rarely 7 cm long, robust form with longest spikes, green to yellowish green while mature, elliptic to linear-oblong, 22-40-flowered, rarely reaching up to 75 in robust form; all alike and isomorphic, slender, androgynous; basal 1-3 glumes sterile; number of sterile glumes up to 15 in robust form; basal 1-7 placed apart; sexuality very distinct at maturity. Pistillate portion basal, 0.3 to 5 cm long, very variable in count, 5-65-flowered, much thicker at maturity; female glumes excluding the projection much shorter than the utricles, 3.5 to 4 mm long, ovate to elliptic, awned or cuspidate, rarely bicuspidate showing twin structure, 1-6 mm long, scabrid, length of projection gradually decreasing from base to apex, green, keeled and 1-3-veined; midrib wide, straw-colored with very wide hyaline margins; stylar base swollen, 2.25 to 2.5 mm long; stigma 2, recurved, much shorter than utricle, 1.5 to 2.5 mm long, surface with long hairy projections. Staminate portion distinct at maturity, terminal, shorter, compact, 0.5 to 20 mm long, to 25-30-flowered; linear to ovate-oblong; male glumes elliptic-lanceolate, basal few awned, upper slightly mucronate, 5 to 6 mm long including projection, single-veined; midvein and awn scabrid; midrib green, otherwise brownish-hyaline. Utricles much flattened, biconvex, ovoid to ellipsoid, large, to 6 mm long, distinctly 6-7-veined and stipitate; stalk up to 1.5 mm long.
gradually narrowed into a long beak; margins thickened, glabrous, faces prominently ribbed, olive-green; beak 1.5 to 2 mm long; aperture hyaline, deeply bifid; margins scabrous. Nuts much flattened, 3/5th of utricle, broadly ovoid, biconcave, lenticular in cross section, 2.25 to 3.0 mm long, distinctly stipitate, closely attached with thin membranous utricle, not easily separable, light brown to dark brown.

**Microcharacters (SEM study):** Utricles with distinct costal and intercostal region; intercostal cells rectangular, elongated, isodiametric; cells tumid; costal cells inconspicuous. Nut surface beaded all through except the stalk and stylopodium having single central silica body; cells polygonal; basal platform of silica body plano-convex, without any ornamentation on basal platform; central body of silica round, distinctly raised or beaded, or lenticular but not conical, devoid of radial bars; secondary silica body absent, satellite and periclinal walls distinct. Cells of stylopodium polygonal, forming a reticulate structure, asymmetrical in diameter, devoid of silica body; cells above stylopodium comparatively longer.

**Anatomy**

Culm: Circular to oval in cross section; one portion of the edge convex or slightly invaginated in transverse section with wavy outline. Specimens studied usually 1cm long. Translucent, spongy ground tissue towards center and devoid of air cavity. Air-cavities: present in peripheral region only, oblong to nearly quadrangular in outline; translucent aerenchyma cells of cavity oval; cavity surrounded by chlorenchyma tissue. Assimilatory tissue: as chlorenchyma present in peripheral region only, 6 to 7 cell-layered thick but interrupted by the presence of air-cavities and the vascular bundles. Vascular bundles: arranged in two rows at peripheral region, nearly 29 in number; 12 major and other minor and arranged more or less alternately with each other; the peripheral minor vascular bundles embedded in chlorenchyma tissue; second row vascular bundles next to peripheral few in numbers and embedded in ground tissue; all vascular bundles oval, with 2-3 large metaxylems, sclerenchyma tissue present on both the ends of vascular bundles; peripheral vascular bundles with sclerenchymatous girders connected with the epidermal layer; the peripheral girder baculiform in shape while the central girder crescentiform in shape; other vascular bundles towards ground tissue surrounded by layer of sclerenchyma cells only. Sclerenchyma tissue: associated with vascular bundles only, present on both the ends of
vascular bundle; sclerenchymatous girder of periphery attached with epidermal layer and baculiform to securiform in shape and sometimes interrupted by the chlorenchyma tissue. In case of minor vascular bundles 1-2 cell layers of sclerenchyma surrounding vascular bundles: major vascular bundles of ground tissue with 3-4 layers of thick sclerenchyma on both the ends and joined with each other by one layer sclerenchyma cells of their own.

Leaf: Lamina widely V-shaped in cross section and dorsiventral; keel prominent and tip of keel slightly protruding and rounded; lamina thickest at and near the keel region, narrower near the hinge portion and gradually tapering towards the margins; tip of margins acute. Specimens studied usually 2 mm long. Epidermis: the adaxial epidermal cells larger than abaxial epidermal cells; cells oblong to oval and of different sizes, never adnored with papilla; the cells over the sclerenchyma comparatively smaller in size in both the cases; cells in the adaxial hinge portion mostly 8 in number, bulliform cells and oblong in shape, vertically elongated; adaxial cuticle thicker than abaxial one. Mesophyll tissue: as chlorenchyma well developed, interrupted by the presence of air cavities and vascular bundles. Sclerenchyma tissue: associated with vascular bundles, present on both the ends of vascular bundles, the layer of sclerenchyma of the ends joined with each other by a single layer of sclerenchyma cells; sclerenchyma cells in hinge or keel portion of vascular bundle adaxial girder connected to the abaxial epidermal layer and horizontal crescentiform in shape as well as adaxial cap-shaped; in other major vascular bundles sclerenchyma forms both adaxial and abaxial sclerenchymatous girder and both the girders connected with epidermal layers; adaxial girders baculiform while abaxial crescentiform in shape; in minor vascular bundles sclerenchyma forming single or double layers surrounding the vascular bundles; distinct patch of sclerenchyma also present at adaxial side of leaf margins attached to the adaxial epidermal layer, never attached with any of the vascular bundles. Vascular bundles: present in a single row, 8-9 in each half of the lamina, 4 major and 5 minor; oval in shape, with large 2 to more metaxylem, associated with sclerenchyma present on both the sides of vascular bundles. Bundle sheath cells double-layered, interrupted by sclerenchyma in both adaxial and abaxial sides in case of major vascular bundles and completely surrounding in case of minor vascular bundles. Air-cavities long oblong in outline, filled with aerenchyma cells; cells rounded to polygonal.
Fig. 140. Habit and inflorescence of *Carex longipes*

A. Habit; B. Inflorescence with arrangement of flowers on spike (in part, diagrammatic).

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Male flower, Female flower, Sterile flower
Plate LXXI. Photographs of habit and inflorescence of *Carex longipes*

1. Habit; 2. Inflorescence(part).
Fig. 141. Morphology of female glumes, female flower, utricle and nut of *Carex longipes*

A. Female glume twin form as rare one; B. 1<sup>st</sup> female glume; C. 2<sup>nd</sup> female glume; D. 4<sup>th</sup> female glume; E. Female glume from top of spike; F. Utricle; G. Beak of utricle with persistent style and stigma; H. Nut with persistent style and stigma; I. T.S. of nut.
Fig. 142. Morphology of stigma, nut and male glumes of *Carex longipes*

A. Beak of utricle and stigmatic surface; B. Nut with cellular surface; C. and D. Male glumes.
Plate LXXII. Scanning electron microphotographs of utricle and nut of *Carex longipes*

Fig. 143. Anatomical features of culm of *Carex longipes*

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 144. Anatomical features of leaf of *Carex longipes*

A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion (cellular); D. Laminar edge(cellular).
Plate LXXIII. Microphotographs of anatomical features of culm and leaf of *Carex longipes*

1. T. S. of culm; 2. A portion of culm (magnified); 3. T. S. of lamina; 4. Laminar groove region; 5. Laminar lateral portion; 6. Laminar edge. Scale bar-1 and 3 (300μm); 2 (150μm) 4, 5 and 6 (200μm).
The subgenus *Vignea* is recognized by many taxonomists and is well differentiated with the following features:

Rhizomes short or creeping. Plants monoecious, rarely dioecious. Spikes usually many, bisexual, androgy nous or gynaecandrous, rarely spikes entirely male or female, ovate, oblong, or orbicular, sessile, arranged in spicate or paniculate structures, or even capitulate appearance of the total inflorescence, rarely paniculiform, or spicate-paniculate appearance also; not prophyllate at base. Stigmas 2, rarely 3. Utricles plano-convex, or biconvex, globose or ellipsoid, rarely inflated. Nuts plano-convex, or biconvex.

**Key to the sections of the subgenus Vignea**

1a. Spikes androgy nous; culms without nodes, not thickened at base, forming nearly single, terminal spike; epidermis of nut devoid of silica body ................................................................. XII. C. sect. *Phleoidae*

1b. Spikes gynaecandrous; culms with nodes, thickened, distantly alternate on an elongate rachis, forming loosely spicate inflorescence; epidermal cells of nut with single silica body, distinct ........................................................................................................... XIII. C. sect. *Remotae*


The section *Phleoidae* is characterized by the following features:

Rhizomes short. Culms tufted. Involucral bracts leafy, setaceous, or glume-like. Spicate inflorescence long, cylindric; lower spikes sometimes shortly branched; spikes numerous, androgy nous. Female glumes ovate or ovate-oblong. Stigmas 2. Utricles winged, or wingless but thickened along margins, membranous, veined; orifice 2-toothed.

**Description**

**Morphology**

**Vegetative morphology:** Perennial herb, 15-55 cm, rare often to 60 cm high, not phyllopodic, caespitose; modules 5-100 per plant, very densely tufted, often matted when dwarf and disturbed. Roots light to dark brown, tomentose. Underground stem as rhizomes very short, not stoloniferous, perennial, tough, hard; Leaves inserted along lower 1/3 of culm, generally as basal cluster of 3-5 and existing for a single season only; leaf-sheath persistent; bases of leaf-sheath straw-colored, at maturity breaking down into dark fibrils at the base of the aerial stem, without reticulation on leaf sheath; bladeless sheath 2-3 also attached at the base along with the sheath of foliage leaves, straw-colored, faintly ribbed, forming an inconspicuous build up at the base; blades variable in length, reaching nearly ½-1/3 of the length of the robust form of the species and nearly reaching the top of the inflorescence in medium sized form, much overtopping in shortest form; blades 23-29 cm and rarely to 35 cm long and 1-1.5 mm wide; length of the blades gradually increasing from base to apex, more or less capillaceous, filiform, V-shaped in cross section, surface more or less glabrous; margins scabrulous; single mid-veined and 2-3 nearly distinct lateral veins on each side.

**Reproductive morphology:** Plant monoecious; culms 20-30 cm or even 50 cm long, longer in robust form but much shorter in the shortest form. Flowering nodes single per module; leaves 3-7, at the base of the stem; leafless in the upper half of the stem; bracts filiform; lower one leafy, present at the base of the inflorescence, lower one much exceeding the inflorescence top, 10-12 cm long and 1-1.5 mm wide, sheath not distinct, persistent; upper bracts gradually decreasing in length; cladophyll absent. Inflorescences forming spicate structure, with single terminal peduncle; 5-10-spiked, dense, ovate to linear, 1.3 to 4.5 cm long, multispicate; lateral spike sessile; individual spike ovate to ovoid, erect, or at right angle to the axis, length of the
spikes variable ranging from 4 to 7 mm; terminal spike longest and nearly 1-1.2 cm long: basal spikes comparatively shorter; all androgynous; glumes 12-30(35) per spike; basal 1-2 sometimes sterile; glumes very compact at maturity. Stamine portion inconspicuous except during anthesis, 1.5-2.5 mm long, 4-7-flowered; staminate glumes inconspicuous, comparatively shorter. 2.5-3 mm, single-veined, elliptic to oblong, acute, without bristle, stramineous; stamens 3, uniform; filaments comparatively longer, about 3 mm long; anthers linear-oblange, 2-2.5 mm long; isomorphic, tip apiculate, crests triangular, without any projection. Pistillate portion distinct, variable in length, 4.5-9.5 cm, 15-30-flowered; pistillate glumes 15-30 per spike; lower glumes shorter than utricles, 2-3 mm long; middle glumes more or less equal to the utricles, 4-4.5 mm long in fruiting, ovate, apiculate to aristate; glumes of middle portion apiculate, not aristate; arista appendiculate and up to 1.5 mm long, single-veined, 3-4.25 mm long; sterile glume single, ovate, hyaline, without midvein; middle part of the glumes around midvein green, other part hyaline; 1'-fertile glume hyaline without midvein; surface of all glumes glabrous; style 0.9-1.2 mm long; stigmas 2, comparatively longer, 2-2.5 mm long; stigmatic surface with fimbriate projections.

Utricles: compressed lenticular at base, ovoid, 2.5-4 mm long at maturity, not stipitate, spreading at maturity, upper half hispidulous, 5-9-veined; veins distinct, cariaceous, with very distinct beak; beak 0.5-0.7 mm long, rarely up to 1.2 mm long, distinctly bidentate, compact at maturity, green to greenish white. Nuts filling the basal half of the utricle at maturity, 1.5-2.2 mm long and 1 mm across, stipitate, globular or globose, lenticular, compressed, light brown.

**Microcharacters (SEM study):** Utricle having very distinct costal cells, serially arranged; each costa made up of 3-7 seriate elongated rectangular cells; intercostal cells indistinct. Nut surface cellular; cell size, shape and outline inconspicuous, totally devoid of any silica body (psilate).

**Anatomy**

Culm: Rounded to hardly triangular, with wavy outline or with ridges and furrows; epidermal cells not adorned the papillate extension, with broadly obtuse corners; the corners broadly rounded; specimens examined generally 0.1 to 0.2 cm long. Ground tissue translucent, spongy, towards the center; true center hollow, without any cells; ground tissue devoid of air cavities and totally devoid of any vascular bundles. Air cavities: mostly present in peripheral
region, oblong in outline, arranged alternately with peripheral vascular bundles, filled with square to transversely oblong aerenchyma cells, surrounded by chlorenchyma cells. Assimilatory tissue: as chlorenchyma present at the periphery region, arranged in 10 to 12 rows, interrupted by the presence of air cavities and vascular bundles; cells small and variable in shape, well developed around minor vascular bundles. Vascular bundles: arranged in the peripheral region in a distinct circle, 18 in number; 9 major and 9 minor alternate to each other; major vascular bundles below the ridges and minor vascular bundles below the furrows, in unequal tissue distribution; minor bundles embedded within the chlorenchyma tissue and major partially in chlorenchyma tissue and partially within ground tissue; generally oval in shape but some rounded in shape, each with 2 metaxylems placed side by side and a pair or group of 4 to 8 metaxylems present just below the 2 metaxylem; sclerenchymatous girders present at both ends of vascular bundle. Sclerenchyma: associated with vascular bundles; peripheral sclerenchyma girder extended up to epidermal layer and attached with the epidermal layer, baculiform; central sclerenchyma cells connected with ground tissue, 4 to 5 cell-layered and deeply crescentiform; in minor vascular bundles sclerenchyma present only at the end in a single row. Bundle sheath cells present in minor vascular bundles but interrupted by sclerenchyma cells in both the sides.

Leaf: Lamina V-shaped in cross section, dorsiventral, thick at keel portion, thin near hinge portion, tapering towards the apex; apex slightly rounded; Epidermis: adaxial cells larger than abaxial cells; cells oblong-ovoid, but barrel-shaped in abaxial layer, cells not adnored with any papillate projection; marginal epidermal cells smaller; in hinge portion the adaxial cells larger, bulliform cells 10, large in comparison to others; cuticular layer thick in adaxial epidermal layer. Mesophyll tissue: chlorenchymatous; cells well developed, 3 to 5 cell-layered thick, oblong, smaller than adaxial epidermal cells, surrounding the air cavities. Sclerenchyma tissue: generally associated with the vascular bundles, present on the both the ends of the vascular bundles, forming girder; in hinge portion the abaxial sclerenchyma girder connected with abaxial epidermal layer and winged crescentiform; adaxial cap of 4 cell-layered thick; in keel portion the girders extended up to the epidermal layer and baculiform on adaxial and securiform on abaxial side. Vascular bundles: arranged in a single row, 5 to 6 in one half of the lamina, 3 major and rest minor, arranged alternately, all oval in shape, with 2 large metaxylems apart and one group of 5 to 6 above the two metaxylem; sclerenchyma girder present both in adaxial and abaxial sides in
major vascular bundles, securiform; minor vascular bundles surrounded by a single row of sclerenchyma cells; a distinct patch of triangular sclerenchyma present near the margins and remain associated with the adaxial epidermal layer. Vascular bundles equidistant from both adaxial and abaxial layers. Air cavities: alternately arranged with vascular bundles, comparatively larger, oval to rectangular in outline, filled with aerenchyma cell; cells transversely oblong to oval; air cavities well surrounded by chlorenchymatous cells. Bundle sheath double cell-layered thick, outer parenchymatous and inner sclerenchymatous, interrupted by the sclerenchymatous cells.
Fig. 145. Habit and inflorescence of *Carex nubigena*

A1 and A2. Habit; B. Inflorescence (diagrammatic) with arrangement of flowers on spike.

Male flower, Female flower, Sterile flower
Plate LXXIV. Photographs of habit and inflorescence of *Carex nubigena*
1. Habit; 2. Inflorescence (magnified).
Fig. 146. Morphology of sterile and female glumes, female flower and utricle of Carex nubigena

A. Sterile glume; B. 1\textsuperscript{st} fertile female glume; C. 2\textsuperscript{nd} female glume; D. 3\textsuperscript{rd} female glume; E. 4\textsuperscript{th} female glume; F. Female glume from upper part of spike; G. Immature utricle with style and stigma.
Fig. 147. Morphology of utricle, nut, male flower and stamens of *Carex nubigena*

A. Utricle splitted open; B. Nut; C. T.S. of nut; D. Male glume with filaments; E. Stamens.
Plate LXXV. Scanning electron microphotographs of utricle and nut of Carex nubigena

Fig. 148. Anatomical features of culm of *Carex nubigena*

A. T. S. of culm(diagrammatic); B. A portion of culm(cellular).
Fig. 149. Anatomical features of leaf of *Carex nubigena*

A. T. S. of lamina (diagrammatic); B. Laminar groove (cellular); C. Laminar lateral portion (cellular); D. Laminar edge (cellular).
Plate LXXVI. Microphotographs of anatomical features of culm and leaf of Carex nubigena

1. T. S. of culm; 2. A portion of culm (magnified); 3. T. S. of lamina; 4. Laminar groove; 5. Laminar lateral part and edge. Scale bar- 1 and 3 (300μm); 2 (50μm); 4 and 5 (150μm).

This section Remotae is characterized as follows:

Involucral bracts leafy, rather long, surpassing inflorescence. Spikes gynaecandrous, distantly alternate on an elongate rachis, forming loosely arranged spicate structure of the total inflorescence. Utricles plano-convex, thinly membranous, rather narrowly winged above, not spongy.


Description (Figs. 150-153; Pls.LXXVII-LXXIX)

Morphology

Vegetative morphology: Plant perennial herb, 20 -50 cm long, caespitose; modules usually 5-20 rarely up to 50 in a group, often matted, densely tufted. Root pale brown–light brown, often slender. Underground and ground level stems rhizomatous, creeping, very short. devoid of stolons, glabrous; basal part of the stems covered with leaf-sheath, persistent, rarely breaking down into fibres; bases of lower sheath pale brown, strongly-ribbed to dark brown, dull. Leaves evenly disposed and well covered the lower 1/3rd part of culm, 3-5, very weak, leathery, much shorter to just equaling the inflorescence top, never outtopping at maturity; blades shorter; top most one generally longest, 17-25 cm long and 1.8-2.5mm wide, flat, surface and margins scabrous, linear in cross section, with single midvein and 1-2 lateral veins; bladeless leaves 3-5, present at base only.

Reproductive morphology: Plant monoecious; culms 10-30 cm long, longer than the leaves. Flowering nodes usually 9-17, or rarely 19 per module; 5-7 (along with bladeless sheath) leaves at the base or in basal 1/3rd part of the culm; upper half of the culm leafless; bracts leafy except the lowest one, present at the base of the spike; lower bracts leafy, hardly equaling to
slightly overtopping to greatly exceeding inflorescence top, 11-16 cm long and 1.5-2.0mm wide: bract-sheath absent; upper bracts gradually decreasing in length and breadth; cladophyll absent. Inflorescence multispicate to multispioid in nature, 6-19-spiked, rarely as less as 6, 9-15 cm long, all sessile; lowest one very distantly placed; lowest spike 2.5-3.5mm away from the second one; individual spike sessile, always erect, ovate to elliptic in outline, 6-12mm, or rarely 15 mm long; protogynous; lower spikes comparatively longer, 10-12mm rarely upto 15mm long; upper gradually shortened; upper few 6-8mm; spikes either adjacent and adpressed to the rachis or placed in acute angle; all spikes gynaecandrous, flowers 15-35 per spike; basal flower rarely neuter; glumes 12-35, all the glumes very compact, never spreading or wide open. Staminate portion very short, inconspicuous, 2-5-flowered, basal in position, 2-3mm long, very compact; glumes comparatively longer, 3-4.5mm; variable in size and shape: 1st male glume ovate, about 4 mm long, apex acuminate and bristled, single mid-veined and 6 lateral veins on each side; base cuneate, hyaline-pale green colored; 2nd male glume obovate, about 4 mm long, apex acute and bristled, single mid-veined and 4-5 lateral incomplete veins on each side of the midvein, hyaline with green midrib; apex of some basal as 3rd glume truncate; apex of some male glumes aristate also and about 1mm long, arista bristled; stamens 3, isomorphic; filaments shorter while young as 1mm and longer at maturity as 4-5 mm long; anthers of equal length and isomorphic, 2.5-2.5 mm long, linear-oblong; anther tip (crest) bluntly apiculate, globular, with fimbriate projections. Pistillate portion distinct, 5-9 mm long, 15-29-flowered; female glumes comparatively longer than utricle, 3.5-4mm long, very compactly arranged, ovate, apiculate to acute, single distinct mid-veined and with several branched lateral veins, hyaline with green colored median portion, glabrous, rarely scabrid at the apex; style comparatively longer, 0.9-1.5 mm long, base bulbous, dilated; stigmas 2, 1.5-1.75 mm long, surface projected. Utricles ellipsoid-lanceolate, 3-3.5mm long at maturity, distinctly stipitate; stalk 0.8-1 mm long; many-veined; upper half hispid, gradually tapered to a beak; beak 0.5-0.8 mm long, distinctly bidentate, yellowish green-coloured. Nuts subovoid-ellipsoid, flattened, 2/3rd of the utricles excluding beak, 1.5-2.5 mm long, light brown-coloured.

Microcharacters (SEM study): Utricle with distinct costal and intercostal regions; cells not distinct and distinguishable; intercostal cells appear to be much more elongated, compressed than the cells of costal region. Nut surface distinctly cellular; cells polygonal, isodiametric. some
of them also elongated, having central conical-rounded silica body; basal platform of silica plano-concave, rounded; central body slightly raised, blunt ended, devoid of any ornamentation of basal platform, satellite body and periclinal wall.

**Anatomy**

*Culm:* Hexa to poly-gonal to nearly rounded, with rounded corners in transverse section; epidermis with wavy outline, with ridge and furrow and not adnored with any kind of projection; specimens examined usually 1mm long. Ground tissue: translucent towards the center, spongy, in maximum portion of the section and without any vascular bundles and air cavities; cells of the ground tissue rounded to polygonal and larger in size. Air-cavities: present in the peripheral region, alternate with the major and minor vascular bundles; outline of the air chamber oval to rectangular; cells of air cavities rectangular and similar in size, surrounded by chlorenchyma cells. Assimilatory tissue: as chlorenchymatous cells, arranged as 8-9 cell layers to the periphery region; cells oblong to rounded, smaller in size in comparison to epidermal and ground tissue cells; chlorenchyma well developed around the minor vascular bundles and air cavities. Vascular bundles: 24, 13 minor and 11 major, all in one circular ring and embedded within chlorenchyma; major vascular bundles below the ridges and minor vascular bundles below the furrows. Major vascular bundles oval in shape and the minor ones rounded to oval in shape; each with 2-3 metaxylems, conspicuous. Sclerenchyma tissue: on both the ends of major vascular bundles and 2-3 cell layers of sclerenchyma in case of minor vascular bundles; peripheral sclerenchyma of the vascular bundle forming the sclerenchymatous girder extending up to the epidermal layer; sclerenchyma in major vascular bundle 6-8 cell-layered in peripheral portion; sclerenchymatous girder securiform and attached with the epidermal layer; central girder ascending crescentiform; in case of minor vascular bundles sclerenchyma 2-3 cell-layered thick and surrounding vascular bundles.

*Leaf:* Lamina widely V-shaped in cross section; hinge portion also slightly V-shaped; epidermal cells of both the adaxial and abaxial surfaces not adnored with the papillate extension; dorsiventrally arranged; keel prominent and protruding with rounded tip; lamina thickest at and near abaxial rib and abruptly tapered towards the margins; margins rounded. Epidermis: adaxial cells oblong in shape and various in sizes; abaxial cells barrel-shaped and also variable size;
adaxial cells much larger than the abaxial cells; adaxial cells of hinge portion very much larger and with 6-7 single-layered bulliform cells; cuticular layer present on both sides, thick in adaxial epidermis and thin in abaxial cells. Sclerenchyma tissue: associated with the vascular bundles, present in both ends of vascular bundles, forming girders; adaxial girders of the hinge vascular bundle horizontal, crescentiform and adaxial cap; abaxial girders crescentiform in the keel vascular bundle; sclerenchyma of 1-2 cell layers surrounding the marginal vascular bundle; abaxial girders attached with the abaxial epidermal layer; patch of sclerenchyma also present at the adaxial portion near the margins forming securiform girders and attached with the adaxial epidermal layer. Vascular bundles: arranged in single row, 6 in each half of lamina, oval in shape; total number of vascular bundle 12-13 in whole lamina; minor 6-7 and major 6, arranged alternately; vascular bundles embedded in chlorenchyma, each with 2 conspicuous metaxylems; sclerenchyma tissue present on both sides of vascular bundles. Air cavities: long rectangular in outline, filled with translucent, transversely oblong to polygonal aerenchyma cells; air-cavities surrounded by well developed chlorenchyma cells. Bundle sheath: cells double-layered; outer parenchymatous and inner sclerenchytamous, interrupted by the presence of sclerenchymatous tissue. Bulliform cells well developed in the adaxial surface, more distinct and different in the groove region of lamina.
Fig. 150. Habit and inflorescence of *Carex rochebrunii*

A. Habit; B. Inflorescence pattern (diagrammatic); C1-C4. Arrangement of flowers of different sexes on spikes (diagrammatic).

- Male flower
- Female flower
- Sterile flower
Plate LXXVII. Photographs of habit and inflorescence of *Carex rochebrunii*

1. Habit; 2. Inflorescence (portion magnified).
Fig. 151. Morphology of female and male glumes, female flower, utricle, stamens of Carex rochebrunii

A. 1st female glume; B. 2nd female glume; C. Utricle; D. Nut with persistent style and stigma; E. 1st male glume; F. 2nd male glume; G. 3rd male glume; H. 4th male glume; I. 5th male glume; J. Stamens.
Plate LXXVIII. Scanning electron microphotographs of utricle and nut of *Carex rochebrunii*

Fig. 152. Anatomical features of culm of Carex rochebrunii

A. T. S. of culm (diagrammatic); B. A portion of culm (cellular).
Fig. 153. Anatomical features of leaf of Carex rochebrunii

A. T. S. of lamina(diagrammatic); B. Laminar groove(cellular); C. Laminar lateral portion(cellular); D. Laminar edge(cellular).
Plate LXXIX. Microphotographs of anatomical features of culm and leaf of *Carex rochebrunii*

1. T. S. of culm; 2. A portion of culm (magnified); 3. T. S. of lamina; 4. Laminar groove; 5. Laminar lateral portion. Scale bar-1(200μm); 2(100μm); 3(300μm); 4 and 5(50μm).
Table 8 Comparison of some vegetative and reproductive morphological features of the studied taxa of *Carex*

<table>
<thead>
<tr>
<th>I. Sl.no.</th>
<th>II. Names of studied taxa</th>
<th>III. Characters of bract</th>
<th>IV. No. of Module/tuft</th>
<th>V. No. of flowering node/module</th>
<th>VI. No. of peduncles/node</th>
<th>VII. No. of spikes/node</th>
<th>VIII. Total flowering glumes and arrangement</th>
<th>IX. Ratio of male and female portions of the spikes</th>
<th>X. Xa In length female: male</th>
<th>Xb In no. of flowers female: male</th>
<th>XI. Arrangement of sexes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Carex baccans</em> Nees</td>
<td>Exceeding inflorescence</td>
<td>2-5</td>
<td>5-6</td>
<td>1(2)</td>
<td>7-18</td>
<td>50-65</td>
<td>Absent</td>
<td>1.5:1</td>
<td>1.5:1</td>
<td>All androgynous</td>
</tr>
<tr>
<td>2.</td>
<td><em>Carex myosurus</em> Nees</td>
<td>Greatly exceeding inflorescence</td>
<td>5-7</td>
<td>8-9</td>
<td>1-3</td>
<td>3-9</td>
<td>50-60</td>
<td>Absent</td>
<td>1:2-1:1</td>
<td>1:1-2:1-3:1</td>
<td>All androgynous</td>
</tr>
<tr>
<td>3.</td>
<td><em>Carex spiculata</em> Boott</td>
<td>Slightly to greatly exceeding inflorescence</td>
<td>5-10</td>
<td>5-7</td>
<td>1</td>
<td>3-12</td>
<td>40-60</td>
<td>Basal 1-2</td>
<td>3:1-4:1</td>
<td>3:1-4:1</td>
<td>All androgynous</td>
</tr>
<tr>
<td>4.</td>
<td><em>Carex composita</em> Boott</td>
<td>Exceeding inflorescence top</td>
<td>12-15</td>
<td>5-7</td>
<td>1</td>
<td>9-17</td>
<td>30-100</td>
<td>Absent</td>
<td>3:1-1:1</td>
<td>3:1-1:1</td>
<td>All androgynous</td>
</tr>
</tbody>
</table>

Continued…..
Table 8 Comparison of some vegetative and reproductive morphological features of the studied taxa of *Carex*

<table>
<thead>
<tr>
<th></th>
<th>II</th>
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<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>Xa</th>
<th>Xb</th>
<th>XI</th>
</tr>
</thead>
<tbody>
<tr>
<td>5b.</td>
<td><em>Carex cruciata</em> Wahl. var. <em>nagporensis</em> C.B.Clarke</td>
<td>Greatly exceeding inflorescence</td>
<td>5-7</td>
<td>5-7</td>
<td>2-3</td>
<td>7-25</td>
<td>100-150</td>
<td>a) 3-4 basal; b) 25 basal; c) 20-25 basal</td>
<td>3:1-4:1</td>
<td>2:1</td>
<td>All androgynous</td>
</tr>
<tr>
<td>6.</td>
<td><em>Carex burttii</em> Noltie</td>
<td>Slightly exceeding inflorescence top</td>
<td>50-70</td>
<td>7-9</td>
<td>1-2</td>
<td>Numerous</td>
<td>15-35</td>
<td>Generally 1 rarely 2</td>
<td>1:2-1:3</td>
<td>1:4-1:5</td>
<td>All androgynous</td>
</tr>
<tr>
<td>7.</td>
<td><em>Carex stramentitia</em> Boott ex Boeckeler</td>
<td>Slightly exceeding inflorescence top</td>
<td>5-7</td>
<td>3-5</td>
<td>1-2</td>
<td>Numerous</td>
<td>12-20</td>
<td>1-2, basal</td>
<td>1:2</td>
<td>1:3-1:4</td>
<td>All androgynous</td>
</tr>
<tr>
<td>8.</td>
<td><em>Carex filicina</em> Nees</td>
<td>Just exceeding inflorescence</td>
<td>5-7</td>
<td>4-6</td>
<td>6-11-15</td>
<td>10-12</td>
<td>Absent</td>
<td>2:1-3:1</td>
<td>1.5:1</td>
<td>All androgynous</td>
<td></td>
</tr>
</tbody>
</table>

Continued......
Table 8 Comparison of some vegetative and reproductive morphological features of the studied taxa of *Carex*

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
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<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>Xa</th>
<th>Xb</th>
<th>XI</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td><em>Carex continuua</em> C.B.Clarke</td>
<td>Just equaling inflorescence top</td>
<td>Up to 50</td>
<td>4-6</td>
<td>1-2</td>
<td>15-24</td>
<td>14-20</td>
<td>Absent</td>
<td>4:1-5:1</td>
<td>2:1-5:1</td>
<td>All androgynous</td>
</tr>
<tr>
<td>10</td>
<td><em>Carex condensata</em> Nees</td>
<td>Slightly to greatly exceeding inflorescence top</td>
<td>30-70</td>
<td>8-9</td>
<td>Mainly 2, rarely 1</td>
<td>Numerous</td>
<td>19-25</td>
<td>1-3, basal</td>
<td>1:2</td>
<td>1:3-1:4</td>
<td>All androgynous</td>
</tr>
<tr>
<td></td>
<td><em>Carex inanis</em> Kunth</td>
<td>Hardy equaling to inflorescence</td>
<td>Up to 100</td>
<td>4-5</td>
<td>More or less absent</td>
<td>1 to each node</td>
<td>Up to 75</td>
<td>2, basal; 4-5, upper</td>
<td>4:1-5:1:1 upper totally male</td>
<td>5:1-6:1</td>
<td>Basal 4-5 androgynous; upper one totally male</td>
</tr>
<tr>
<td>11</td>
<td><em>Carex setigera</em> D.Don</td>
<td>Greatly exceeding inflorescence top</td>
<td>30-35</td>
<td>7-10</td>
<td>One to each node</td>
<td>3-11</td>
<td>60-100</td>
<td>Absent</td>
<td>1:2</td>
<td>1:2-1:3</td>
<td>a) androgynous; b) totally male; c) totally female</td>
</tr>
<tr>
<td>12</td>
<td><em>Carex breviculmis</em> R. Br.</td>
<td>Greatly exceeding inflorescence</td>
<td>Up to 100</td>
<td>4-5</td>
<td>Almost absent</td>
<td>1 to each node</td>
<td>6-60</td>
<td>Absent</td>
<td>4:1-11:1; upper totally male</td>
<td>4:1-10:1</td>
<td>Basal 4-5 androgynous; upper one totally male</td>
</tr>
<tr>
<td>13</td>
<td><em>Carex speciosa</em> Kunth</td>
<td>Equalling to or slightly exceeding inflorescence</td>
<td>2-20</td>
<td>1-2 rarely 3</td>
<td>1-2</td>
<td>Generally 1, rarely 2</td>
<td>More than 40</td>
<td>1-2, basal</td>
<td>1:1-1.5:1</td>
<td>1:1-1:3</td>
<td>All androgynous</td>
</tr>
</tbody>
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Continued......
Table 8 Comparison of some vegetative and reproductive morphological features of the studied taxa of *Carex*

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<th>V.</th>
<th>VI.</th>
<th>VII.</th>
<th>VIII.</th>
<th>IX.</th>
<th>Xa</th>
<th>Xb</th>
<th>XI.</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.</td>
<td><em>Carex daltonii</em> Boott</td>
<td>Greatly exceeding inflorescence top (twice of the length)</td>
<td>3-5</td>
<td>5-7</td>
<td>2-28</td>
<td>2-35</td>
<td>15-40</td>
<td>2-3, basal</td>
<td>variably</td>
<td>variably</td>
<td>Basal totally female; middle androgynous; upper totally male</td>
</tr>
<tr>
<td>16.</td>
<td><em>Carex insignis</em> Boott</td>
<td>Shorter or just equaling inflorescence top</td>
<td>10-20</td>
<td>7-10</td>
<td>1-5</td>
<td>5-10</td>
<td>Up to 90</td>
<td>Up to 25, basal, middle, upper</td>
<td>10:1-3:10</td>
<td>1:10-1:30</td>
<td>Mostly androgynous; sometimes totally male</td>
</tr>
<tr>
<td>17.</td>
<td><em>Carex polyccephala</em> Boott</td>
<td>Equaling inflorescence</td>
<td>2-4</td>
<td>3-5</td>
<td>2-7</td>
<td>2-7</td>
<td>40-70</td>
<td>Absent</td>
<td>2:1-3:1</td>
<td>3:1-6:1</td>
<td>All androgynous</td>
</tr>
<tr>
<td>18.</td>
<td><em>Carex finitima</em> Boott</td>
<td>Exceeding inflorescence top</td>
<td>3-5, up to 20</td>
<td>3-5</td>
<td>1 to each node</td>
<td>1</td>
<td>Female 85-90; male 55-60</td>
<td>Absent</td>
<td>4:1</td>
<td>5:5:1</td>
<td>Basal 3-4 spikes female; topmost one totally male</td>
</tr>
<tr>
<td>19.</td>
<td><em>Carex alopecuroides</em> D. Don ex Tilloch &amp; Taylor</td>
<td>Lower exceeding but upper equaling inflorescence top</td>
<td>2-5</td>
<td>4-6</td>
<td>One to each</td>
<td>generally 1, rarely 2</td>
<td>134-224</td>
<td>Terminal one with several sterile glumes, position not fixed</td>
<td>5:1-6:1</td>
<td>3:1</td>
<td>Basal 4-5 female; terminal one variously arranged</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
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<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>Xa</th>
<th>Xb</th>
<th>XI</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Carex teres Boott</td>
<td>Exceeding inflorescence top</td>
<td>2-5</td>
<td>4-6</td>
<td>1</td>
<td>1, rarely 2 (terminal)</td>
<td>210-400</td>
<td>20-25, basal</td>
<td>5:1-6:1</td>
<td>5:1-6:1</td>
<td>Basal 2-3 female; topmost various (gynaecandrous, mesogynous)</td>
</tr>
<tr>
<td>21</td>
<td>Carex longipes D. Don ex Tilloch &amp; Taylor</td>
<td>Slightly exceeding inflorescence top</td>
<td>5-10</td>
<td>5-12</td>
<td>1</td>
<td>1-3</td>
<td>22-30</td>
<td>1-3, basal</td>
<td>2:1, 3-1-5:1</td>
<td>1.5:1-2:1</td>
<td>Mostly androgynous; basal totally female</td>
</tr>
<tr>
<td>22</td>
<td>Carex nubigena D. Don ex Tilloch &amp; Taylor</td>
<td>Half of the length to equaling to inflorescence top</td>
<td>50-100</td>
<td>1-2</td>
<td>1</td>
<td>5-10</td>
<td>15-30</td>
<td>1-2, basal</td>
<td>5:1</td>
<td>5:1</td>
<td>All androgynous</td>
</tr>
<tr>
<td>23</td>
<td>Carex rochebrunii Franchet &amp; Savatier</td>
<td>Equalling to or slightly exceeding inflorescence top</td>
<td>20-50</td>
<td>8-9</td>
<td>Absent</td>
<td>1</td>
<td>25-35</td>
<td>8-10 (rarely), top</td>
<td>10:1</td>
<td>6:2-25:2</td>
<td>Gynaecandrous (basal male, upper female)</td>
</tr>
</tbody>
</table>
5.3 Key to the studied species of Carex L.

5.3.1 Artificial key to the studied species based on morphological characters

1a. Inflorescence simple to compound, spicate to paniculate; spikes few to many, bisexual, all androgynous; stigmas generally 3, rarely 2................................................................................................................. 2

1b. Inflorescence spicate, spikes few to many, unisexual or both unisexual and bisexual (sometimes variable in sexuality); stigmas 3, rarely 2.......................................................................................... 3

2a. Length of spikes generally more than 2 cm; with 2-3 orders of lateral paracladia; spikes evenly distributed.................................................................................................................. 15

2b. Length of spikes generally less than 2 cm; with secondary paracladia of 3-4 order present; spikes compactly arranged ................................................................. 18

3a. Spikes sessile, comparatively shorter......................................................................................... 4

3b. Spikes stalked (atleast lower few), comparatively longer......................................................... 5

4a. Sexuality gynaecandrous; stigmas 2; epidermal cells of nut with distinct single silica body ................................................................................................................................. C. rochebrunii

4b. Sexuality androgyrous; stigmas 3; silica body absent in the epidermal cell of nut ......................................................................................................................... C. nubigena

5a. Peduncles 1-3(4) per flowering node, gradually decreasing in length towards apex........... 6

5b. Number of peduncles more than 5 per flowering node, sometimes upto 28, all peduncles of different length........................................................................................................... 7

6a. Terminal spike totally male, or variable in sexuality............................................................. 9

6b. Terminal spike androgyrous, or totally male................................................................. 11

7a. Spikes stout, comparatively shorter; length of spike not related with sexuality of spike, even male spike with shortest length; nuts distinctly stipitate ......................... C. polycephala
7b. Spikes lax, weaker, longer; maleness increases with the increase of length of spike (longest spike totally male); nuts not stipitate........................................................................................................................................8

8a. Glumes loosely arranged; female glumes not awned or aristate; base of stem deep red (glistening red); leaves shorter, throughout the stem and culm, bladeless leaf-sheath present even after maturity..................................................................................................................C. insignis

8b. Glumes compactly arranged (except basal 2-3); both male and female glumes distinctly aristate or awned; base of the stem pale brown; leaves longer, much overtopping; bladeless sheath absent........................................................................................................................................C. daltonii

9a. Lower peduncle distantly placed, longer; all the male glumes and basal few female glumes long aristate .........................................................................................................................C. finitima

9b. Lower peduncle not so distantly placed, shorter; both male and female glumes not aristate................................................................................................................................................................10

10a. Bracts not sheathing; spikes shorter; plant shorter; utricles distinctly veined; stigmas 3..........................................................................................................................C. alopecuroides

10b. Bracts sheathing; spikes longer; plant longer; veins of utricles not distinct; stigmas-2...................................................................................................................................................C. teres

11a. Spikes developed just from few cm above the ground; multiple modules within a common cluster of leaves; stigma very short, recurved .................................................C. speciosa

11b. Spikes not from the ground level; single module in a leaf cluster; stigma long, not recurved................................................................................................................................................................12

12a. Leaf-blade wider, to 7 mm; spikes elongated; utricles hispidulous (except beak), biconcave-flattened; stigmas 2 .........................................................................................................................C. longipes

12b. Leaf blade narrower, to 2.5 mm; spikes comparatively shorter; utricles not hispidulous (except beak), trigonous; stigmas 3 ........................................................................................................13
13a. Plant short, to 30 cm long, erect-semierect, sometimes decumbant; breaking leaf-sheath of previous year not distinct ...................................................................................................

\[ C. \text{ inanis} \]

13b. Plant long, to 60 cm, erect; leaf-sheath of previous year distinct, or sometimes breaking down into elongated fibres .............................................................................................................. 14

14a. Lowest flowering node often more distant; spikes 30-35 per module; wings of female glumes subequal .............................................................................................................................

\[ C. \text{ setigera} \]

14b. Lowest flowering node not so distant, spikes 5-7(9) per module; wings of female glume equal .............................................................................................................................

\[ C. \text{ breviculmis} \]

15a. Utricles comparatively shorter, less than 3 mm; upper half of utricles hispidulous; beak of the utricles short; anther crests distinct .............................................................................................................................

\[ C. \text{ composita} \]

15b. Utricles comparatively longer, more than 3 mm; surface of utricle glabrous (not hairy); beak long, distinctly bidentate; anther crests not distinct .............................................................................................................................16

16a. Female glumes awned or cuspidate, broad, longer; mature utricles/fruits bright red, with indistinct veins .............................................................................................................................

\[ C. \text{ baccans} \]

16b. Female glumes apiculate or acuminate, comparatively shorter; mature utricle brown, distinctly veined .............................................................................................................................

\[ C. \text{ spiculata} \]

17a. Silica body of the epidermal cell of nut conical; outline of epidermal cells not clear; mature inflorescence stout, pale brown; male portion of the spike often spreading and blunt ended .............................................................................................................................

\[ C. \text{ myosurus} \]

17b. Silica body of the epidermal cell of nut slightly raised; outline of epidermal cells distinct; mature spike/inflorescence slightly drooping (much drooping at maturity), deep brown; male portion of spike conical, or pointed .............................................................................................................................

\[ C. \text{ myosurus} \]

18a. Panicle pyramidal .............................................................................................................................

\[ C. \text{ myosurus} \]

18b. Panicle linear oblong-elongated (not pyramidal) .............................................................................. 22
19a. Beak of utricle deflexed/reflexed, comparatively longer, and not bidentate (with oblique aperture); female glumes and utricles with blackish brown unique glandular spots
.................................................................................................................................................. C. filicina

19b. Beak of utricle straight, comparatively shorter, bidentate; female glumes and utricles devoid of glands .................................................................................................................................................. 20

20a. Leaf-sheaths and both the male and female glumes with pale brown streaks; leaf-blades much wider; immature inflorescence typical cream-coloured; tip of female glume muticous; anther crests distinct........................................................................................................... C. stramentitia

20b. Leaf-sheath and both the male and female glumes without streaks; leaf-blades less wide; immature inflorescence green; female glumes not muticous; anther crests not distinct
.................................................................................................................................................. 21

21a. Mature utricles glistening white, often infected by smut fungi; vegetative phase comparatively shorter .............................................. C. cruciata var. argocarpus

21b. Mature utricles greenish-pale brown, never infected by smut; vegetative phase robust................................................................................................................................................................. C. cruciata var. nagporensis

22a. Female flowers more in comparison to count of male flowers; terminal portion of spike represented by very few male flowers; spikes very distantly placed, never in groups ........
.................................................................................................................................................. C. continua

22b. Female flowers less in comparison to count of male flowers; terminal portion with more male flowers; spikes are in group of 5-9(12). ................................................................. 23

23a. Spike(s) long, to 12 mm; linear, shining brown to reddish brown.................... C. condensata

23b. Spike(s) short, generally to 7 mm; ovate-elliptical, pale brown......................... C. hurttii
5.3.2. Artificial key to the studied species based on anatomical characters

1a. Outline of lamina in t. s. V-shaped, or flat (margins not flanged)............................................. 2

1b. Outline of lamina in t. s. inverted W-shaped and margins often flanged ................................. 3

2a. Culm or flowering stem in t. s. triangular in outline ............................................................... 6

2b. Culm or flowering stem in t. s. not triangular in outline ........................................................ 7

3a. Hinge region of lamina made up of single layer of cells......................................................... 4

3b. Hinge region of lamina made up of more than one layers of epidermal cells............................. 5

4a. Keel of lamina protruding; apex of keel not rounded (acute), generally terminated by single conical silica body ................................................................. 8

4b. Keel of lamina protruding; apex rounded, generally not terminated by any extension............ 9

5a. Culm in t. s. triangular with acute angles (corners); major and minor vascular bundles in two concentric rings; massive ground tissue and pith devoid of any vascular bundles and air chambers; adaxial epidermal cells hugely adorned with papillae..............................C. teres

5b. Culm in t. s. broadly triangular with rounded angles (corners); major and minor vascular bundles in two complete circles and in one incomplete circle; ground tissue with irregularly arranged vascular bundles; pith narrow; adaxial epidermal cells not adorned with papillate extension.............................................................C. buttii

6a. Hinge region of the lamina made up of 2-unequal layers of epidermal cells, cells of the upper layer of hinge epidermis comparatively larger, longer and vertically elongated.....C. daltonii

6b. Hinge region of the lamina made up of single layer of epidermal cells................................. 17

7a. Vascular bundles of culm in two to more concentric rings; pith conspicuous or inconspicuous................................................................................................................. 15

7b. Vascular bundles of culm in single peripheral ring; pith conspicuous............................... 16
8a. Adaxial epidermal cells of lamina adnored with papillae or silica body
8b. Adaxial epidermal cells of lamina not adnored with papillae

9a. Hinge region made up of 2-3 layers of epidermal cell
9b. Hinge region made up of single layer of epidermal cell

10a. Culm in t. s. roughly triangular in outline
10b. Culm in t. s. distinctly triangular in outline

11a. Epidermis of culm adnored with prickle/papillae; vascular bundles of outer circle not alternating with any air cavity
11b. Epidermis culm or flowering stem devoid of any papillate extension; vascular bundles of outer circle alternating with large conspicuous air chamber

12a. Epidermal cells of hinge portion several times larger than other epidermal cells
12b. Epidermal cells of hinge not distinguishable from other epidermal cells

13a. Margins of the lamina more curved; lamina wider
13b. Margins of the lamina not so curved; lamina comparatively narrower

14a. Epidermis of stem wavy; hinge cells as like as other adaxial epidermal cells
14b. Epidermis of stem not wavy; hinge cells several times larger than other epidermal cells

15a. Adaxial epidermal cells of lamina adnored with papillae; hinge cells similar to other epidermal cells; patch of sclerenchyma absent at edge of lamina
15b. Adaxial epidermal cells not adnored with papillae; hinge cells comparatively larger than other epidermal cells; edge of lamina with a patch of sclerenchyma
16a. Hinge region made up of 1-2 layers of epidermal cells; hinge cells as like as other epidermal cells; number of vascular bundles in each half of the lamina 5-6. .......................................................... C. nubigena

16b. Hinge region made up of single layer of epidermal cells; hinge cells comparatively larger than other epidermal cells; number of vascular bundles in each half of the lamina more than 7 ........................................................................................................................ C. rochebrunii

17a. Abaxial epidermis of the lamina hugely adnored with papillae…………… C. alopecuroides

17b. Abaxial epidermis of lamina not adnored with papillae...................................................... 18

18a. Keel or hinge region of lamina distinctly protruding on abaxial side and often terminated with conical silica body................................................................. 19

18b. Keel or hinge region of the lamina not protruding and even without any silica body .......................................................................................................................... 20

19a. Adaxial epidermal cells often adnored with papillae or conical silica bodies ................................................................. C. Cruciata var. nagporensis

19b. Adaxial epidermis not adnored with any extensions or papillae ............................... 21

20a. Outline of culm or flowering stem acutely triangular (atleast one corner).……… C. finiitima

20b. Outline of culm or flowering stem broadly triangular (with blunt ended corner) .......................................................................................................................... 22

21a. Number of hinge cells more than 15; air cavities of the lamina comparatively smaller .................................................................................................................. C. cruciata var. argocarpus

21b. Number of hinge cells less than 15; air cavities or aerenchyma of lamina wider ...................................................................................................................................... C. baccans

22a. Peripheral sclerenchyma girders not attached with any of the major or minor vascular bundles; vascular bundles in 4-5 or even more concentric rings (distributed throughout ground tissue and pith); pith inconspicuous .............................................. C. insignis
22b. Peripheral sclerenchyma girders always associated at least with the major vascular bundles; vascular bundles in 2-3 or less concentric rings; pith conspicuous..............................................23

23a. Hinge cells less than 7; hinge cells comparatively larger than other adaxial epidermal cells................................................................. C. inanis

23b. Hinge cells more than 7; hinge cells as like as other adaxial epidermal cells ........................................................................................................ C. breviculmis
5.4 Mycorrhizal association in Carex L.

Out of 28 individual populations of Carex L. assessed for mycorrhizal association, 25 were found infected and 3 were without any colonization. Arbuscular mycorrhiza were found in 11 out of 28 populations of Carex sampled with the occurrence percentage of 41.37% in Carex cruciata, C. teres, C. nubigena, C. filicina, C. inanis, C. setigera, C. finitima, C. composita and C. myosurus (Pls. LXXX-XCII). Details of this observation are provided in table 10.

Examinations of the root hairs of different species of Carex L. revealed differences in morphological features and these were correlated with the mycorrhizal species status. The root hairs for the majority of species of Carex L., under study, were usually quite long, greater than 1mm and sparsely distributed. In some species as C. rochebrunii (plate XCII), the roots were covered with fine layers of comparatively distinct short hairs. The roots are somewhat variable in morphological features and are distinguished by their bulbous swellings at base. These are sometimes topped by filamentous root hairs as also found in C. rochebrunii, C. longipes, C. setigera and C. finitima (Pls. XCII, XC, LXXXVI and LXXXVIII respectively). They always form mats covering the every surface of roots. The presence of bulbous-based root hairs was negatively associated with the presence of mycorrhizal association. In fact C. rochebrunii with these bulbous swelling roots were found not to be infected but the other species with these structures had many other different types of associations in the slide. Further study revealed the presence of mycorrhizal association in other sections of the roots. Other species with arbuscules were either with dense root hairs or completely lacking. The species like C. teres, C. nubigena, C. myosurus (Pls. LXXXIX, XCI and LXXXI) do not have any root hairs but C. finitima and C. cruciata (Pls.LXXXVIII and LXXXIII) has short dense root hairs. In some specimens the presence of fungal spore were also noticed both inside the root cells and outside the root vicinity as found in C. teres, C. filicina, C. inanis, C. cruciata, C. finitima, and C. composita (Pls. LXXXIX, LXXXIV, LXXXV, LXXXIII, LXXXVIII and LXXXII). Mycelial type of association was of common occurrence with highest percentage (86.20%) as observed in all the studied specimens. There was the only difference in the individual of same species. Even vesicles are also much observed and also quite in occurrence with the percentage of 75.86%. The hyphae were hyaline and well ramified.
Out of 28 samples 25 were infected either with arbuscules, vesicles, mycelium, and fungal spores or sometimes with dark septate endophytic fungi. Mycorrhizal association in *Carex* is present in higher amount than accounted before by many workers as Harley and Harley (1987), Tester *et al.* (1987), Newman and Reddell (1987); Miller *et al.* (1999), Muthukumar *et al.* (1996, 1997) and Muthukumar and Udayan (2000a). Because all *Carex* species examined were not present at all sampled site and thus could not definitely attribute site related effects of differences in environmental variables, since were noted from wetlands with running water (*C. teres, C. finitima* and *C. rochebrunii* etc.), whereas some species were from quite dry region among the slopes (*Carex cruciata* and *C. myosurus*) or in the walls or even above the rocks (*Carex insignis*).

The observed data (Table 9) clearly indicates that where there is less concentration of phosphorous in soil there is the maximum intensity and type of mycorrhizal infections. The phosphorous contains in soil in quite low and the species *C. teres, C. nubigena, C. filicina, C. inanis*, etc. are growing with mycorrhizal association. The concentration of phosphorous is relatively higher incidence of mycorrhizal appearance in general and arbuscular mycorrhiza in particular is low as found in species of *C. rochebrunii* and *C. insignis*. Even for the same species of different population of *C. rochebrunii* and even in *C. inanis* there seem to have been a different type of association due to variations of habitat conditions. Based on present study it cannot solely be concluded on this mere observation of phosphorous availability and that it directly affects the mycorrhizal status in plants. This differences had been reported due to seasonal fluctuations as noted by Muthukumar and Udayan (2000). It was even stated by Miller *et al.* (1999) that the mycorrhizal association and phosphorous availability in soil is less or not related.

But in this study it was also observed that high phosphorous availability in soil was negatively correlated with mycorrhizal association as found in *C. rochebrunii* and *C. insignis*, whereas low concentration of phosphorous led to well establishment as in the case of *C. nubigena* and *C. finitima*. Even when there was low phosphorous content the association was noticed between plant specimen and mycorrhiza, and on the same specimens when the phosphorous content was little higher there was no or a very little association (*C. rochebrunii* and *C. inanis*). In the mid range, mycorrhizal association was observed in most of the specimens of *C. filicina, C. composita* and *C. inanis*. By this observation it can be concluded that phosphorous availability in
soil is inversely related to mycorrhizal association as stated by Allen et al. (1987); Rickerl et al. (1994); Rabb et al. (1999); Muthukumar and Udaian (2000).

The observation presented in other studies and the present findings indicate that the extent of mycotrophy in the genus Carex is much greater than that had been realized before. Harley and Smith (1983) mentioned the family Cyperaceae as “Non mycotrophic”. Bagyaraj et al. (1979) observed that Cyperus eleusinoides Kunth (aquatic macrophyte) was not colonized by mycorrhizal fungi. However, they considered that the establishment of association was not favoured in plants due to aquatic habitat. Studies performed in different areas by Koske and Halvorson (1981), Malloch and Malloch (1982), Brundrett and Kendrick (1988) and Louis (1990) did not find any colonization in the species of this genus. However, Kobresia myosuroides was found to form ectomycorrhiza growing in the artic area (Kohn and Stasovski, 1990). Bledose et al. (1990) have considered that arbuscular mycorrhizal associations are rare in high artic area, and probably has a small or no importance in improving growth and nutrition of species in such environment. Presence of arbuscular mycorrhizal and other forms in members of Cyperaceae (Carex spp.) as seen here confirm the observation of other authors like Harley and Harley (1987), Miller et al. (1999). Muthukumar and Udaian (2000) suggested that in genus Carex L., taxonomic and environmental factors have influenced the mycorrhizal status. Hence based on the observations, Cyperaceae should not be in the non-mycorrhizal group, since the strong evidence of association in several species of this family does exist.

In this study most of the species were typically mycorrhizal and some depends on environmental factors as in C. rochebrunii, 3 out of 4 studied specimens were non-mycorrhizal and the last one also only showed mycelial type of association. C. rochebrunii being “Flood-tolerant” and the influence of environment may have been the major cause, since its habitat is with high moisture content. Due to this there may have been the fluctuations in the occurrence of mycorrhiza. Morphologically some Carex species of Cyperaceae produce swollen dauciform roots with long hairs when growing in nutrient deficient and poorly drained soil (Davies et al., 1973; Lamnot, 1974). It is believed that similar proteoid roots may be morphological adaptation to the non-mycorrhizal condition (Lamnot, 1993). The occurrence of root hairs increases the
nutrient uptake and its abundances increase under low nutrient condition (Foshe and Jungk. 1983; Foshe et al., 1991).

Moreover, abundance of root hairs and the length of root hairs are negatively correlated with mycorrhizal dependency or benefit (Baylis, 1975). In this study unique morphology of root hairs was found in some species as *C. rochebrunii*, *C. longipes*, *C. setigera* and *C. composita*, etc. Where the morphology of root hairs was quite different. The root hairs with bulbous swelling base in *C. rochebrunii* found non-mycorrhizal condition and in other cases where present mycorrhizal incidence was very low. This characteristic feature gives the unique root hair morphology with bulbous swellings, which is associated with the non-mycorrhizal condition. This morphological feature or the “fuzziness” in roots have been used by authors like Reznicek (1986) for description and identification of species. These root hairs also can be the consequence of adaptation as the hair production of root in *Carex* has been shown to increase under soil anoxia (Moog and Janiesh, 1990). Such a pre-adaptation to non-mycorrhizal condition might have allowed sedges to colonize in wetland (Dickman, 1984). Hence the occurrence of the bulbous based root hairs and non-mycorrhizal state may have been coincidental. The fuzziness in roots may have been resulted as the consequence of water-logged condition. Even this character is not consistently present in other species. This study even clearly showed the presence of VAM which were present within the roots of the sedges and correlated with other studies in reference to VAM association (Tester et al., 1987; Koske et al., 1992; Muthukumar et al., 1996, 1997; Muthukumar and Udaiyen, 2000a). In this study even most association types as arbuscules, vesicles, hyphal spores and dark septate hyphae, endophytic fungi were found. Moreover, many authors had described the presence of non-mycorrhizal families with intercellular development of fungal hyphae often associated with the formation of *Glomus* type vesicles (Giovannetti and Sbrana, 1998) which usually occur after arbuscules development in VAM host. The vesicles produced by VAM fungi are considered to function as storage organs and when with multi-layered propagules can be isolated from the roots (Biermann and Lindermann, 1983). Studies reveal that intra-radical hyphae could take up carbon from the host cell interface (Solaiman and Saito, 1997; Douds et al., 2000). Further, root systems of adjacent plant species or individuals can be linked through the VAM fungal hyphal network in soil. These connections could be involved in nutrient and carbon transport (Robinson and Fitter, 1999) which could be of major significance for the survival of
mycorrhizal species in sedges dominated plant communities. It was even noted in the present study that some species like *C. nubigena, C. cruciata* were colonized by unidentified dark septate fungus that too was reported in species of *Carex* from arctic and alpine sites (Jumpponen and Trappe, 1998). Recently Miller *et al.* (1999) reported the association of dark septate fungi in species of *Carex* from savannas and to our knowledge this is the first report of its presence from this North Eastern Himalayan Region. Finally, past studies have documented fewer spores in wetland species (Anderson *et al.*, 1984) but here they were frequent in appearance with occurrence percentage of 34.48% in some specimens as *C. teres, C. filicina, C. inanis, C. longipes, C. cruciata, C. finitima* and *C. myosurus* (Pls.LXXXIX, LXXXIV, LXXXV, XC, LXXXIII, LXXXVIII and LXXXI respectively). Although presence of mycorrhizal association have been frequently reported by other authors this is the first report of its presence, association and abundance in the genus *Carex* from Eastern Himalayan Region.
Table 9 Details of the available phosphorous in soil with mycorrhizal incidence

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Names of the studied taxa</th>
<th>Date of collection</th>
<th>Concentration (microgram per ml)</th>
<th>Concentration (per gram of soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>Carex myosurus Nees</td>
<td></td>
<td>1. 06/06/10 0.14</td>
<td>0.0014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. 15/07/10 0.13</td>
<td>0.0013</td>
</tr>
<tr>
<td>II</td>
<td>Carex composita Boott</td>
<td></td>
<td>1. 10/08/10 0.15</td>
<td>0.0015</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. 10/08/10 0.17</td>
<td>0.0017</td>
</tr>
<tr>
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<td>Carex cruciata Wahl.</td>
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<td>1. 29/06/10 0.15</td>
<td>0.0015</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. 15/07/10 0.10</td>
<td>0.0010</td>
</tr>
<tr>
<td>IV</td>
<td>Carex filicina Nees</td>
<td>1. 06/06/10 0.14</td>
<td>0.0014</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. 14/06/10 0.18</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. 30/07/10 0.13</td>
<td>0.0013</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. 30/07/10 0.19</td>
<td>0.0019</td>
<td></td>
</tr>
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<td>V</td>
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<td></td>
<td></td>
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<tr>
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<td>2. 29/06/10 0.10</td>
<td>0.0010</td>
<td></td>
</tr>
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<td>2. 07/07/10 0.12</td>
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</tr>
<tr>
<td>VIII</td>
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<td>0.0011</td>
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<tr>
<td></td>
<td></td>
<td>2. 30/07/10 0.12</td>
<td>0.0012</td>
<td></td>
</tr>
<tr>
<td>IX</td>
<td>Carex teres Boott</td>
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<td>1. 30/05/10 0.08</td>
<td>0.0008</td>
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<td></td>
<td></td>
<td>2. 14/06/10 0.15</td>
<td>0.0015</td>
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<tr>
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<td>Carex nubigena D.Don ex Tilloch &amp; tylor</td>
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<td>3. 06/06/10 0.22</td>
<td>0.0022</td>
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<td></td>
<td>4. 15/07/10 0.08</td>
<td>0.0008</td>
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</table>
Table 10 Details of the information of collection and mycorrhizal status of the studied specimens of *Carex*

<table>
<thead>
<tr>
<th>I. Sl. no.</th>
<th>II. Names of the species</th>
<th>III. Places of collection</th>
<th>IV. Dates of collection</th>
<th>V. Types Infections</th>
<th>VI. Presence of bulbous root hair</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td><em>Carex myosurus</em> Nees</td>
<td>1. Grave yard, Darjeeling</td>
<td>1. 06/06/10</td>
<td>M, V, A(Paris type)</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Mall Road, Darjeeling</td>
<td>2. 15/07/10</td>
<td>M, V</td>
<td>(-)</td>
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<tr>
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<td><em>Carex composita</em> Boott</td>
<td>1. Lava Bazar, Darjeeling</td>
<td>1. 10/08/10</td>
<td>M, S,A</td>
<td>(+)</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>2. 10/08/10</td>
<td>M, V, S</td>
<td>(+)</td>
</tr>
<tr>
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<td>1. 29/06/10</td>
<td>M, V, S</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Mall Road, Darjeeling</td>
<td>2. 15/07/10</td>
<td>M, V, A D.S.H</td>
<td>(-)</td>
</tr>
<tr>
<td>IV</td>
<td><em>Carex filicina</em> Nees</td>
<td>1. Senchel, Darjeeling</td>
<td>1. 06/06/10</td>
<td>M, V</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Senchel, Darjeeling</td>
<td>2. 14/06/10</td>
<td>M, H, V</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Rangbull, Darjeeling</td>
<td>3. 30/07/10</td>
<td>M, V</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Rangbull, Darjeeling</td>
<td>4. 30/07/10</td>
<td>V, S</td>
<td>(-)</td>
</tr>
<tr>
<td>V</td>
<td><em>Carex inanus</em> Kunth</td>
<td>1. Senchel, Darjeeling</td>
<td>1. 14/06/10</td>
<td>M, V, S,A</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Govt.College compound,</td>
<td>2. 15/07/10</td>
<td>M, V, E.F</td>
<td>(-)</td>
</tr>
</tbody>
</table>

A=arbuscule; M=mycelial; V=vesicle; DSH=dark septate hyphae; E. F=endophytic fungi; (-) absent, (+) present.

Continued........................
Table 10 Details of the information of collection and mycorrhizal status of the studied specimens of *Carex*

<table>
<thead>
<tr>
<th>I.</th>
<th>II.</th>
<th>III.</th>
<th>IV.</th>
<th>V.</th>
<th>VI.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI</td>
<td><em>Carex setigera</em> D. Don</td>
<td>1. Senchel, Darjeeling</td>
<td>1. 29/06/10</td>
<td>V, M, A</td>
<td>(+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Senchel, Darjeeling</td>
<td>2. 29/06/10</td>
<td>M</td>
<td>(-)</td>
</tr>
<tr>
<td>VII</td>
<td><em>Carex insignis</em> Boott</td>
<td>1. Lebong, Darjeeling</td>
<td>1. 07/07/10</td>
<td>M</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Lebong, Darjeeling</td>
<td>2. 07/07/10</td>
<td>M, V</td>
<td>(-)</td>
</tr>
<tr>
<td>VIII</td>
<td><em>Carex finitima</em> Boott</td>
<td>1. Rangbull, Darjeeling</td>
<td>1. 30/07/10</td>
<td>M, V, A, S</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Rangbull, Darjeeling</td>
<td>2. 30/07/10</td>
<td>M, V, S, A</td>
<td>(-)</td>
</tr>
<tr>
<td>IX</td>
<td><em>Carex teres</em> Boott</td>
<td>1. Senchel, Darjeeling</td>
<td>1. 30/05/10</td>
<td>A, V, S, M</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Senchel, Darjeeling</td>
<td>2. 14/06/10</td>
<td>M, V, S, A</td>
<td>(-)</td>
</tr>
<tr>
<td>X</td>
<td><em>Carex longipes</em> D. Don ex Tilloch &amp; Taylor</td>
<td>1. Senchel, Darjeeling</td>
<td>1. 14/06/10</td>
<td>M, H, V,</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Grave yard, Darjeeling</td>
<td>2. 15/07/10</td>
<td>M, V, S</td>
<td>(+)</td>
</tr>
<tr>
<td>XI</td>
<td><em>Carex nubigena</em> D. Don ex Tilloch and Taylor</td>
<td>1. Senchel, Darjeeling</td>
<td>1. 14/06/10</td>
<td>M, V, A(Paris type)</td>
<td>(-)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Senchel, Darjeeling</td>
<td>2. 29/06/10</td>
<td>M, V, D.S.F</td>
<td>(-)</td>
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<tr>
<td>XII</td>
<td><em>Carex rochebrunii</em> Franchet &amp; Savatier</td>
<td>1. Senchel, Darjeeling</td>
<td>1. 30/05/10</td>
<td>(-)</td>
<td>(+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Grave yard, Darjeeling</td>
<td>2. 06/06/10</td>
<td>(-)</td>
<td>(+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Grave yard, Darjeeling</td>
<td>3. 06/06/10</td>
<td>(-)</td>
<td>(+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Mall Road, Darjeeling</td>
<td>4. 15/07/10</td>
<td>M</td>
<td>(+)</td>
</tr>
</tbody>
</table>

A=arbuscule; M=mycelial; V=vesicle; DSH=dark septate hyphae; E. F=endophytic fungi: (-) absent, (+) present.
Plate LXXX. Photographs habit, roots and secondary fibrous roots of *Carex* spp.

1. Plant of *Carex* sp. with core of rhizosphere; 2-3. Root system of *Carex* spp.; 4-9. Fibrous secondary roots of different species of *Carex* under KOH(10%) treatment (for mycorrhizal study). Scale bar - 1(10 cm); 2(5 cm); 3 (2.5 cm); 4-9 (2.5 cm)
Plate LXXXI. Microphotographs of roots of *Carex myosurus* (different sectional view)

1. Intraradical mycelia (M) and vesicle (V); 2,3. Intraradical spores (S); 4 and 6., Arbuscules in root cells (A) and 5. Intraradical fungal reproductive structures (FRS). Scale bar–1, 3 and 5 (300μm); 2, 4 (100μm); 6 (20μm).
Plate LXXXII. Photograph of habit and microphotographs of roots of *Carex composita* (different sectional view)

1. Habit with roots; 2. Intraradical spore (S); 3. Intraradical mycelia (M) and vesicle (V); 4. Intraradical dark septate hyphae (DSH); 5. Fungal reproductive structures (FRS); 6. Intraradical other endophytic fungi (OEF). Scale bar-2, 3 and 4 (300μm); 5 (100μm); 6 (50μm).
Plate LXXXIII. Microphotographs of roots of *Carex cruciata* (different sectional view)

1. and 2. Intraradical mycelia (M) and vesicle (V); 3. Intraradical dark septate hyphae (DSH);
4. Intraradical mycelia (M); 5. Spores (S); 6. Vesicle (V). Scale bar-1, 2, 5 and 6(300μm); 3 and 4(100μm).
Plate LXXXIV. Microphotographs of roots of *Carex filicina* (different sectional view)

1. Intraradical and extrametrical hyphae and vesicles (V); 2. and 3. Intraradical dark septate hyphae (DSH); 4. Arbuscle (A) forming region of root; 5. Intraradical and extramatrical hyphae (EMH) and fungal reproductive structure (FRS); 6. Intraradical fungal reproductive structure (FRS). Scale bar-1 , 2, 3 and 4(300μm); 5(100μm); 6(20μm).
Plate LXXXV. Microphotographs of roots of *Carex inanis* (different sectional view)

1. and 2. Intraradical mycelia (M) and Vesicle (V); 3 and 5-6. Intraradical hyphae of endophytic fungi; (EF) 4. Fungal reproductive structure (FRS). Scale bar-1(300μm); 2, and 3(200μm); 4 and (100μm); 5(50μm); 6(20μm).
Plate LXXXVI. Photograph of habit and microphotographs of roots of Carex setigera (different sectional view)

1. Plant habit; 2. Intraradical mycelium (M) and spore (S); 3-5. Intraradical mycelium (M) and other endophytic fungal reproductive structure (OEF); and 6. Mycelium (M) and vesicle (V). Scale bar–1 (5cm); 2(50μm); 3 and 5(300μm); 4 and 6(100μm).
Plate LXXXVII. Microphotographs of roots of *Carex insignis* (different sectional view)

1. Vesicle (V) and intraradical hyphae; 2. Intraradical mycelia (M). Scale bars—1 (50 μm); 2 (100 μm).
Plate LXXXVIII. Microphotographs of roots of *Carex finitima* (different sectional view)

1. Root hairs with bulbous base (BRH); 2, 3 and 4. Vesicle (V) and intraradical and extramatrical hyphae; 5, 6. Extramatrical (EMH) and intraradical hyphae (M).

Scale bar-1, 3 and 5 (50μm); 2, 4 and 6 (300μm).
Plate LXXXIX. Microphotographs of roots of *Carex teres* (different sectional view)

1. Vesicles (V); 2. Extramatrical (EMH) and intraradical hyphae; 3. and 4. Spores (S) of *Paris* type endomycorrhizal fungi; 5. Arbuscular root (A); 6. Intraradical mycelium with reproductive structures (S). Scale bar 1-4 (20 μm); 5 and 6 (300 μm).
Plate XC. Microphotographs of roots of *Carex longipes* (different sectional view)

1., 3., and 4. Vesicles (V); 2. Mycelia (M); 5. and 6. Spores (S). Scale bar-1, 2 and 6 (200µm); 3, 4, and 5 (50µm).
Plate XCI. Microphotographs of roots of *Carex nubigena* (different sectional view)

1, 2 and 3. Intraradical hyphae (M) and vesicles (V); 4. Root cells with arbuscule (A); 5. Dark septate hyphae with appressorium (DSH). Scale bars – 1, 2, 3 and 5(100μm); 4(50μm)
Plate XCII. Photographs of habit and microphotographs of roots of *Carex rochebrunii* (different sectional view)

1. Plant habit; 2. and 5. Intraradical mycelia (M); 3. Dense layer of fine root hairs covering the majority of the fibrous root (typical root hairs of non-mycorrhizal fungi); 4. Bulbous base of root hairs (BRH); 5. Extraradical mycelium (M). Scale bars –1 (5cm); 2 and 4(100μm); 3 and 5(300μm).