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Cuscuta campestris Yunck.: An emerging threat to the indigenous flora of Assam, India

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Abstract. *Cuscuta campestris* is a well-known holoparasitic angiosperm of the family Convolvulaceae. This leafless, rootless, achlorophyllous angiospermic parasite rapidly expands through its diverse host range. This species also shows self-parasitism. The study recorded 92 host species; *Mikania micrantha* and *Christella dentata* being the most preferred hosts. In this manuscript, the taxonomic description of *C. campestris*, its host range, the anatomy of infected host parts and the nature of parasitism are described. This parasite can bring great loss in sectors like agriculture or horticulture by affecting the economically important host plants. This invasive neophyte must be controlled as soon as possible.

Keywords: Assam, *Cuscuta campestris*, host range, parasite, experiments on parasitism.

1. Introduction

The genus *Cuscuta* is a significant group of plants that shows various degrees of parasitism. To meet the need of their nutrition they partially or totally depend on different hosts by anchoring to different parts of the plant body with the help of a special structure known as haustorium. They form parasitic connection non-specifically with a diverse range of hosts from herb to shrub, vines to trees, annual to perennial as well as from terrestrial to aquatic ones.

The genus *Cuscuta* is widely distributed globally and is better known for its parasitic nature. From recent molecular analysis and phylogenetic works, *Cuscuta* genus has been shifted to family Convolvulaceae (APG IV). Around 200 parasitic species of this Genus *Cuscuta* are distributed throughout the temperate, tropical and sub-tropical regions of the world, Americas being the centers of diversity (Yuncker, 1932). In India there are about 12 species documented so far, and in Assam only two species have been reported till now.

All the species of the genus *Cuscuta* are usually achlorophyllous, rootless obligate parasites with re-duced vegetative characters. These leafless parasitic species are only minimally photosynthetic, sometimes have vestigial leaves (Kelly, 1992), and totally dependent on their host (Kelly et al., 2001). The members trail or dextrorsely twin on the hosts through many haustaria (Costea et al., 2008). But interestingly they are found to self-parasitize as well as hyper-parasitize (Liao et al., 2005).

The members of the genus *Cuscuta* reported to show homoplasy for morphological characters, like indehiscence of fruit (Stefanovic et al., 2007), features of pollen (Gwo-Ing et al., 2005; Welsh et al., 2010), and some characteristics of gynoecium (Wright et al., 2011).

In Asam, *C. reflexa* has been studied extensively so far. Recently, *C. campestris* or the Golden dodder plant was reported for the first time from the state (Das & Nath, 2022).

2. Materials and method

2.1. Study area

The survey was extensively carried out in different parts of Kamrup Metro district of the state Assam, India. The state contains a very rich floral diversity and have to main river system Brahmaputra and Barak. The state also is represented by various geographic conditions from hilly areas to valleys. The state is also diversified in terms of ethnic communities (Fig. 1).

2.2. Data collection and analysis

The survey was conducted for two successive years (from January 2019- January 2021). Frequent field visits were carried out to record the host range, and their connectivity through haustoria, affect on the host plant body. For these anatomical sections were prepared by dissecting the portion of the junction between host and parasite, slides were prepared by following the double staining process. Specimens were identified with the help of taxonomic literatures and were compared and confirmed in GUBH (Gauhati University Herbarium).

2.3. Anatomy of infected parts

To ensure the connections of *C. campestris* with hosts through haustorium, anatomical sections of infected parts were done. Double staining method was used to differentiate different parts of the section (Fig. 4).

2.4. Experiment on degree of Parasitism

To study the nature of parasitism, matured seeds of *C. campestris* were collected during field survey. The seeds were allowed to germinate on an experimentally setup work place. The used soil was collected randomly from field without considering any specific quality. The seeds were sown on 25th of April, 2021 without maintaining any specific temperature, humidity. Seeds were allowed to grow naturally in experimental pots with minimal amount of water supply. They started germinating on 27th of April, 2021 (3rd Day). On fourth day, the seedlings then transferred to another pot having two *Mikania micrantha* plants as the model host. The seedlings were simply put 4.5cm away from the host. Data were collected; photographs were taken, per day to observe the growth of the parasite till it destroyed the host completely.

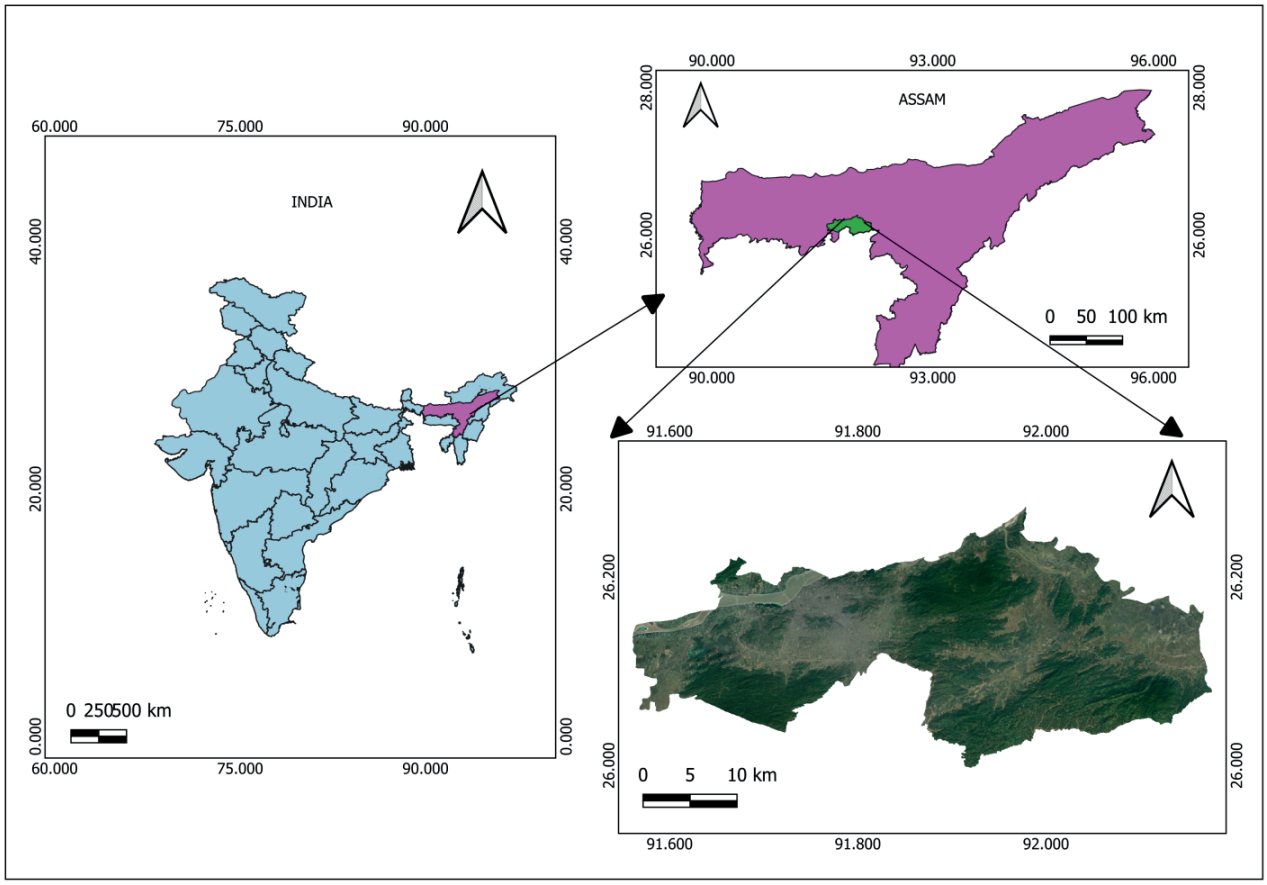

Figure 1. Maps showing study area

3. Results and discussion

3.1. Taxonomic description

Cascuta campestris Yuncker, Mem. Torrey Bot. Club. 18: 138. 1932

Achlorophyllous, leafless, obligate stem parasite; slender stem, yellow to light orange in colour, usually leafless or reduced to scalelike structures; inflorescence compact lateral clusters; flower sessile or shortly pedicellate, actinomorphic, bisexual, whitish, bracts scaly; calyx fused, persistent, 5 lobed, glandular; corolla campanulate, fused, persistent, whitish to cream in colour, 5 lobed; infrastaminal scales fimbriate, reaching upto stamens, epipetalous persistent stamens, subulate filaments; ovary globose, style filiform, stigma capitate; membranous capsule, irregularly dehiscent; seed endospermous,2-4 seeds per capsule, seed with one flattened side, scabrous, brownish (Das & Nath, 2022).

Flowering & fruiting: Throughout the whole year.

3.2. Host range of *Cuscuta campestris*

The species *C. campestris* is being newly reported from the state of Assam which is morphologically quite different from its related species *C. reflexa* (Das & Nath, 2022) (Fig. 2). From extensive observation, it is very important to note that *C. reflexa* shows very specific host range while *C. campestris* shows a wide range of host. Here, the parasite is found to form parasitic connection with 92 plant species plants (Table 1) out of which 9 species belong to monocots and 3 species belong to pteridophytes and the rest of the host plants belong to dicotyledonous group. They belong to 78 different genera under 45 taxonomic families.

Most of the host species are indigenous plants. It is also found that almost all the host species are herbaceous to shrubby in nature. The tree species which are reported to be the infected by *C. campestris* are found in the young stages only (e.g. *Codiaeum variegatum*, *Morus alba*, *Ziziphus*

Table 1. List of hosts of *C. campestris*

Sl. No.	**Host plant species***	**Family**	**Habit**	**Infected parts****
1.	*Achyranthes aspera* L.	Amaranthaceae	Herb	L/S/I
2.	*Acmella paniculata* (Wall. ex DC.) R.K. Jansen	Asteraceae	Herb	S
3.	*Ageratum conyzoides* L.	Asteraceae	Herb	S/I
4.	*Ageratum houstonianum* Mill.	Asteraceae	Herb	S
5.	*Alternanthera* paronychioides A.St.-Hil.	Amaranthaceae	Herb	S
6.	*Alternanthera philoxeroides* (Mart.) Griseb.	Amaranthaceae	Herb	S
7.	*Alternanthera sessilis* (L.) R.Br. ex DC.	Amaranthaceae	Herb	S
8.	*Amaranthus spinosus* L.	Amaranthaceae	Herb	S/I
9.	*Amaranthus viridis* L.	Amaranthaceae	Herb	S
10.	Argyreia nervosa (Burm.f.) Bojer	Convolvulaceae	Climber	S
11.	*Barleria cristata* L.	Acanthaceae	Shrub	S
12.	*Blumea lacera* (Burm.f.) DC.	Asteraceae	Herb	S
13.	Distimake vitifolius (Burm.f.) Pisuttimarn & Petrongari	Convolvulaceae	Climber	S
14.	*Cardamine hirsuta* L.	Brassicaceae	Herb	S
15.	*Cardiospermum halicacabum* L.	Sapindaceae	Climber	S/L
16.	*Christella dentata* (Forssk.) Brownsey & Jermy	Thelypteridaceae	Herb	Fr
17.	*Chromolaena odorata* (L.) R.M.King & H.Rob.	Asteraceae	Herb	S
18.	*Cissus quadrangularis* L.	Vitaceae	Climber	S
19.	*Citrullus lanatus* (Thunb.) Matsum. & Nakai	Cucurbitaceae	Climber	S
20.	*Citrus limon* (L.) Osbeck	Rutaceae	Shrub	S
21.	*Cleome houtteana* Schltdl.	Cleomaceae	Herb	S
22.	*Cleome rutidosperma* DC.	Cleomaceae	Herb	S/F
23.	*Clerodendrum infortunatum* L.	Verbanaceae	Shrub	S
24.	*Codiaeum variegatum* (L.) Rumph. ex A.Juss.	Euphorbiaceae	Herb	S
25.	*Colocasia esculenta* (L.) Schott	Araceae	Herb	P
26.	*Commelina benghalensis* L.	Commelinaceae	Herb	S/L
27.	*Crassocephalum crepidioides* S.Moore	Asteraceae	Herb	S
28.	*Crateva religiosa* G. Forst.	Capparaceae	Tree	S
29.	*Cuphea carthagenensis* J.F.Macbr.	Lythraceae	Herb	S

Table 1. cd

Sl. No.	**Host plant species***	**Family**	**Habit**	**Infected parts****
30.	*Cyanthillium cinereum* (L.) H.Rob.	Asteraceae	Herb	S
31.	*Cynodon dactylon* (L.) Pers.	Poaceae	Herb	L
32.	*Cyperus rotundus* L.	Cyperaceae	Herb	Ped
33.	*Diplazium* esculentum (Retz.) Sw.	Athyriaceae	Herb	Fr
34.	*Eclipta prostata* (L.) L.	Asteraceae	Herb	S
35.	*Enydra fluctuans* Lour.	Asteraceae	A.H	S/L
36.	*Euphorbia hirta* L.	Euphorbiaceae	Herb	S
37.	*Evolvulus nummularius* (L.) L	Convolvulaceae	Herb	S
38.	*Ficus hispida* L.f.	Moraceae	Tree	S
39.	*Grona triflora* (L.) H.Ohashi & K.Ohashi	Fabaceae	Herb	S
40.	*Hygrophila ringens* (L.) R.Br. ex Spreng.	Acanthaceae	Shrub	S
41.	*Impatiens tripetala* Roxb.ex DC.	Balsaminaceae	Herb	S
42.	*Imperata cylindrica* (L.) Raeusch.	Poaceae	Herb	Ped
43.	*Ipomoea aquatica* Forssk.	Convolvulaceae	Herb	S/P
44.	*Ipomoea cairica* (L.) Sweet	Convolvulaceae	Herb	S
45.	*Ipomoea carnea* Jacq.	Convolvulaceae	Herb	S
46.	*Lantana camara* L.	Verbanaceae	Shrub	S
47.	*Leucas aspera* Link	Lamiaceae	Herb	S
48.	*Ludwigia perennis* L.	Onagraceae	Herb	S/F
49.	*Luffa aegyptiaca* Mill.	Cucurbitaceae	Climber	S, P
50.	*Mikania micrantha* Kunth	Asteraceae	Climber	S
51.	*Mimosa pudica* L.	Mimosaceae	Herb	S
52.	*Morus alba* L.	Moraceae	Tree	S
53.	*Nelsonia canescens* (Lam.) Spreng.	Acanthaceae	Herb	S
54.	*Oenanthe javanica* DC.	Apiaceae	Aq.Herb	Ped
55.	*Oxalis corniculata* L.	Oxalidaceae	Herb	P
56.	*Oxalis debilis* Kunth.	Oxalidaceae	Herb	Ped
57.	*Parthenium hysterophorus* L.	Asteraceae	Herb	S
58.	*Persicaria chinensis* (L.) H.Gross	Polygonaceae	Shrub	S
59.	*Persicaria hydropiper* (L.) Delarbre	Polygonaceae	Herb	S
60.	*Persicaria orientalis* (L.) Spach	Polygonaceae	Shrub	S/L/P
61.	*Phyla nodiflora* (L.) Greene	Verbanaceae	Herb	S
62.	*Phyllanthus reticulatus* Poir.	Phyllanthaceae	Herb	S
63.	*Pogostemon benghalensis* Kuntze	Lamiaceae	Herb	S
64.	*Polygonum plebeium* R.Br.	Polygonaceae	Herb	S
65.	*Pongamia pinnata* (L.) Pierre	Fabaceae	Tree	S, P
66.	*Pontederia crassipes* Mart.	Pontederiaceae	Aq. Herb	P
67.	*Pontederia hastata* L.	Pontederiaceae	Aq. Herb	P
68.	*Pouzolzia zeylanica* (L.) Benn.	Urticaceae	Herb	S
69.	*Pteris biaurita* L.	Pteridaceae	Herb	Fr
70.	*Ranunculus sceleratus* L.	Ranunculaceae	Aq. Herb	S/P
71.	*Ricinus communis* L.	Euphorbiaceae	Shrub	S
72.	*Rorippa indica* (L.) Hiern	Brassicaceae	Herb	S
73.	*Rumex nepalensis* Spreng.	Polygonaceae	Herb	S
74.	*Sagittaria trifolia* L.	Alismataceae	Aq. Herb	P
75.	*Scoparia dulcis* L.	Scrophulariaceae	Herb	S
76.	*Senna hirsuta* (L.) H.S.Irwin & Barneby	Caesalpiniaceae	Herb	S, R
77.	*Senna tora* (L.) Roxb.	Caesalpiniaceae	Herb	S
78.	*Sida rhombifolia* L.	Malvaceae	Herb	S
79.	*Solanum nigrum* L.	Solanaceae	Herb	S
80.	*Solanum virginianum* L.	Solanaceae	Herb	S
81.	*Spermacoce alata* Aubl.	Rubiaceae	Herb	S

Table 1. cd

Sl. No.	Host plant species*	Family	Habit	Infected parts**
82.	*Stellaria wallichiana* Haines	Caryophyllaceae	Herb	S
83.	*Stephania japonica* var. *discolor* (Blume) Forman	Menispermaceae	Climber	S
84.	*Sterculia villosa* Roxb. ex Sm.	Sterculiaceae	Tree	S, P
85.	*Synedrella nodiflora* (L.) Gaertn.	Asteraceae	Herb	S
86.	*Syngonium podophyllum* Schott.	Araceae	Climber	S
87.	*Teucrium viscidum* Blume	Lamiaceae	Herb	S
88.	*Tridax procumbens* L.	Asteraceae	Herb	P
89.	*Triumfetta rhomboidea* Jacq.	Tiliaceae	Herb	S
90.	*Urena lobata* L.	Malvaceae	Herb	S
91.	*Xanthium strumarium* L.	Asteraceae	Herb	S
92.	*Ziziphus mauritiana* Lam.	Rhamnaceae	Tree	S

*Plant names according to WFO (2024).
**Explanation: I – Inflorescence, L – Leaf, F – Fruit, Fr – Frond, P – Petiole, Ped- Peduncle, R – Rachis, S – Stem.

mauritiana etc.). Host plants attacked by *C. campestris* show diverse range of habitat. Some grow in open dry sunny places, others in semi-aquatic habitat or in aquatic habitat.

From the current study we found that the most preferred hosts (Primary hosts) are *Mikania micrantha* and *Christella dentata*.This invasive parasite also preys on invasive plants like *Lantana camara*, *Parthenium hysterophorus*, *Pontederia crassipes* etc.

Economically important plants such as *Citrullus lanatus*, *Luffa aegyptiaca*, *Ricinus communis*, *Citrus* x *limon* have also been recorded to be infected by this neophytic parasite.

3.3. Experiment on degree of Parasitism

The result of the experimental evidence is given sequentially in the Figure 5, 6, and 7. The sowed seeds of the parasite started to germinate on the 3rd day (Fig. 5A & 5B). A rootless, acotyledonous stem emerged from the seed. After successful transfer, it started to bend and move towards the host from 5th day (Fig. 5D). It started coiling anti-clockwise around the host's stem on the 6th day (Fig. 5E & 5F). After successful adhesion, the seedling started to penetrate by forming haustorium on 7th day (Fig. 5G & 5H). The seedling started

Figure 2. A- Hosts with *C. reflexa*, **B**- Hosts with *C. campestris*

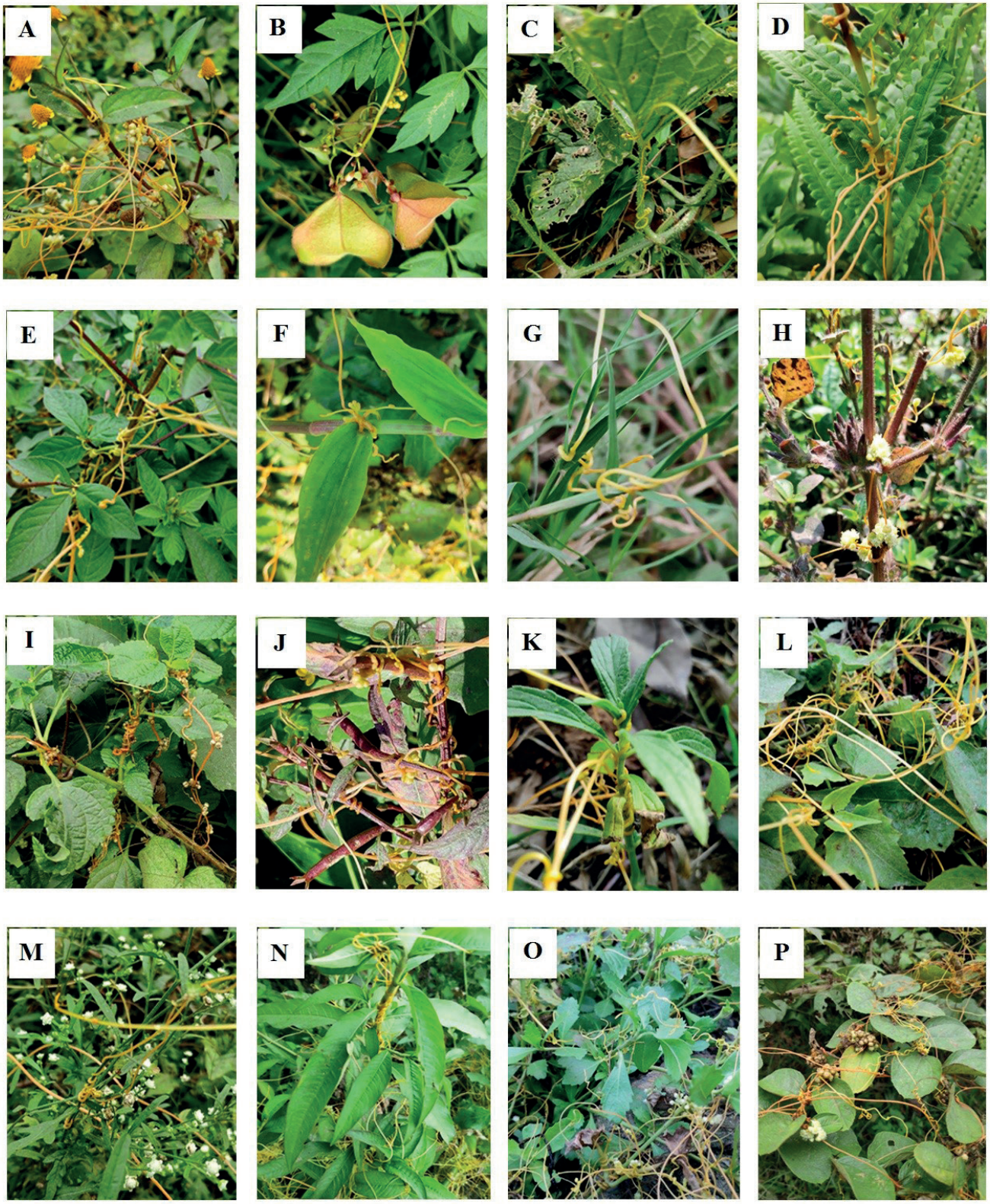

Figure 3. Hosts with *C. campestris*: **A** – *Acmella paniculata*, **B** – *Cardiospermum halicacabum*, **C** – *Citrullus lanatus*, **D** – *Christella dentata*, **E** – *Cleome rutidosperma*, **F** – *Commelina benghalensis*, **G** – *Cynadon dactylon*, **H** – *Hygrophilaringens*, **I**- *Lantana camara*, **J** – *Ludwidia perrenis*, **K** – *Leucas aspera*, **L** – *Mikania micrantha*, **M**- *Parthenium hysterophorus*, **N** – *Persicaria orientalis*, **O** – *Phyla nodiflora*, **P** – *Ziziphus mauritiana*

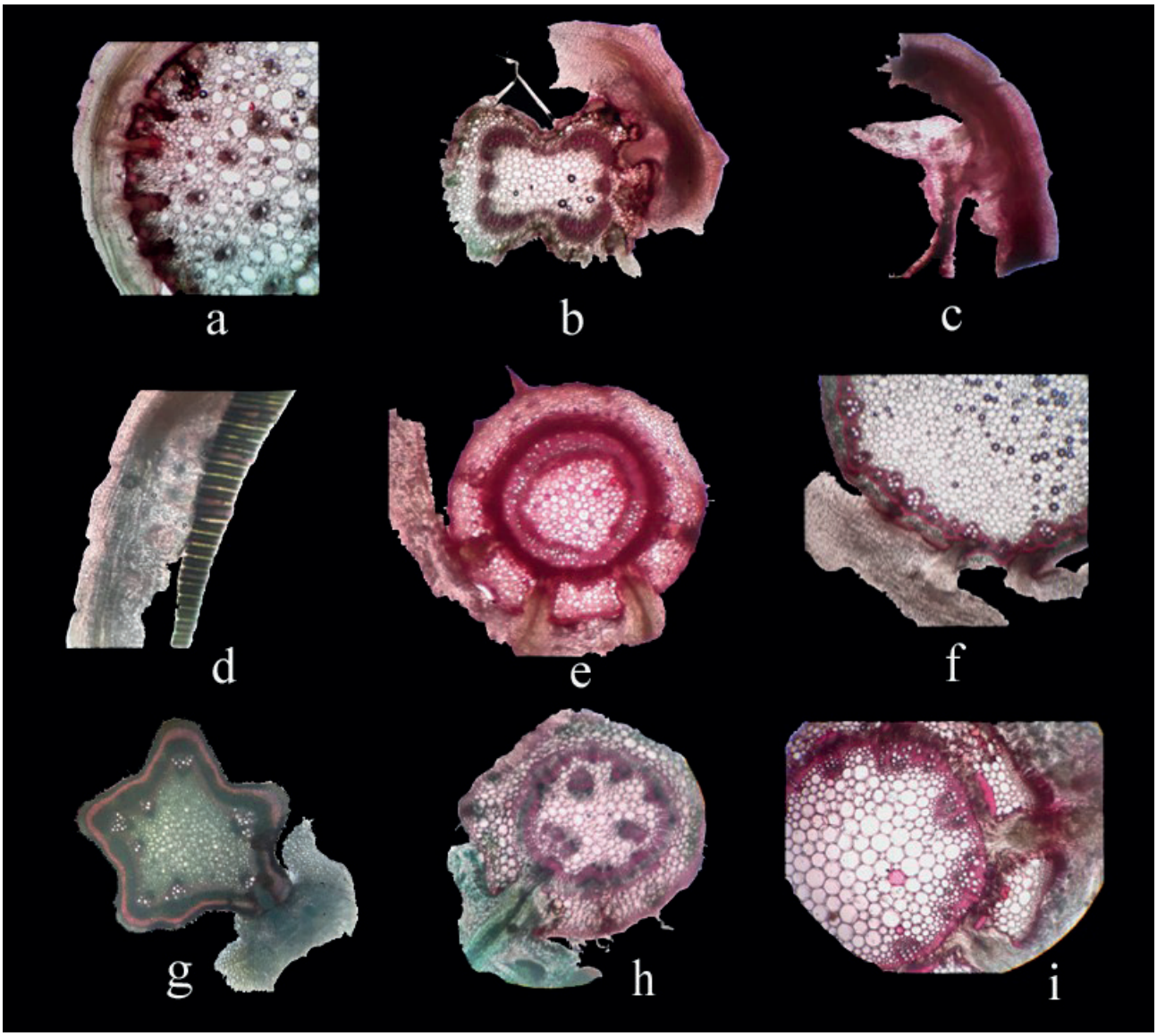

Figure 4. T.S. of **a**: *Colocasia esculenta* (petiole); **b**: *Hygrophyla ringens* (stem); **c**: *Commelina benghalensis* (petiole); **d**: *Cynodon dactylon* (leaf); **e**: *Cuphea carthagenensis* (stem); **f**: *Persicaria chinensis* (stem); **g**: *Cardiospermum halicacabum* (stem); **h**: *Achyranthes aspera* (stem); **i**: *Pouzolzia zeylanica* (stem). Arrows indicating haustorium

growing vigorously and started branching. It nearly covered the whole host and developed many haustorial connections to absorb the nutrition from the host. Around 26th day (Fig. 7A & 7B), it developed floral buds in matured stems. It requires more nutrition for the blooming of flowers. Due to excessive absorption of nutrition, leaves of the host started to die from 27th day (Fig. 7C & 7D). The flowers started blooming at 29th day (Fig. 7G & 7H). The host showed drastic drying of its vegetative parts. On the 33rd day (Fig. 7O & 7P) from the germination of the seedling, the host was completely killed by the parasite.

This experiment proves that *C. campestris* is a holoparasitic plant which requires a host plant for nutrition and water to complete its life cycle (Dawson et al., 1994). The seedlings which were not transferred near the host, died at very young stage; this is due to lack of chlorophyll in the parasite. But under controlled condition it can be grown without a host if provided with proper growth media (Galeano et al., 2022). The one which established proper host-parasite connection survived and even produced flowers.

The germination pattern of the genus *Cuscuta* was studied by various workers prior to this work (Kuijt, 1969; Dawson et al.,1994). The seed after germination formed a rootless, leafless, loop-like structure (Fig. 5B) as plumule remains enclosed within the seed when it comes out to the soil surface. The basal portion of the seedling is swollen, smooth, root-like but it does not have root cap (Lyshede, 1985).

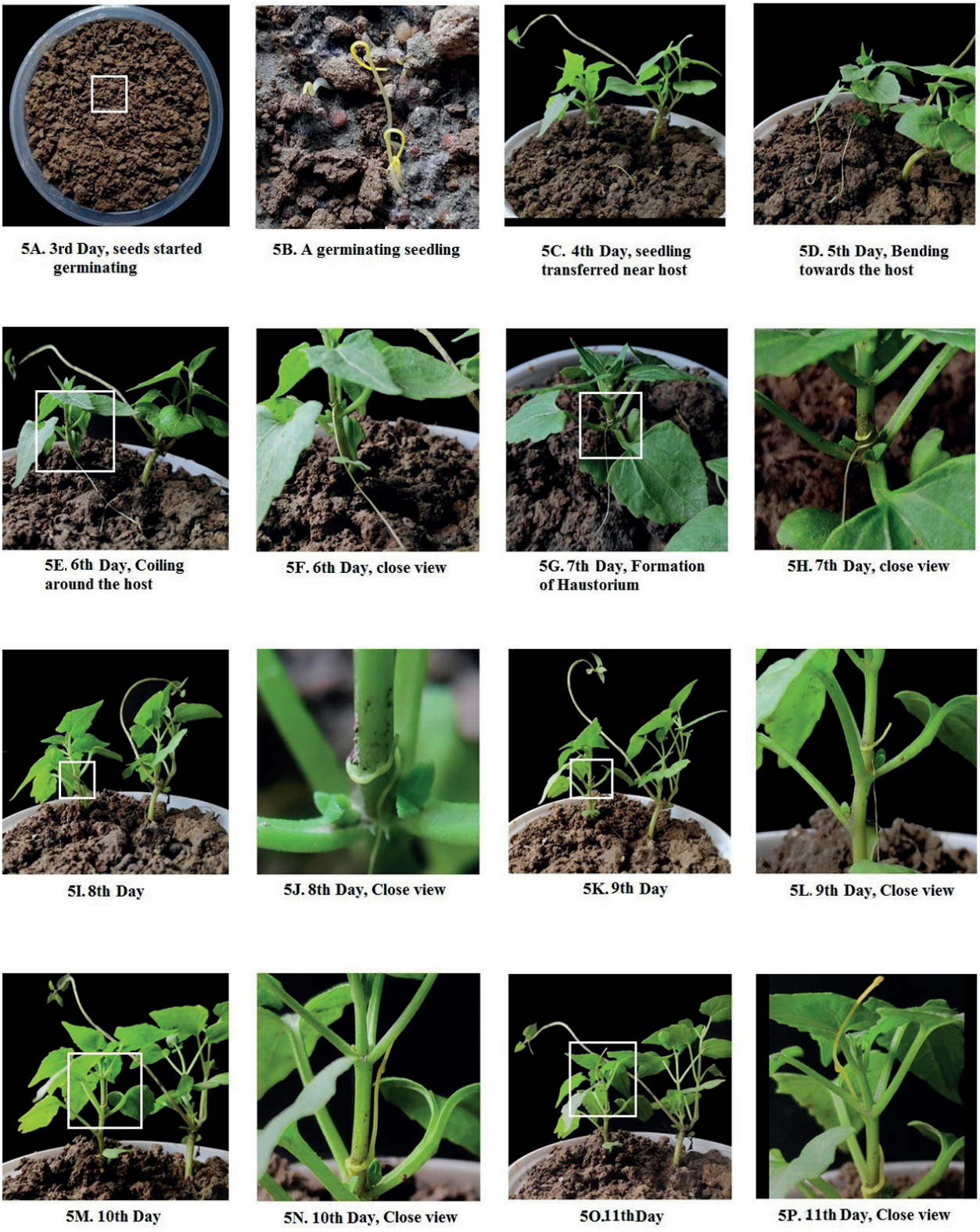

Figure 5(A–P). Experiment on parasitism of *C. campestris* on *M. micrantha*

Figure 6(A–P). Experiment on parasitism of *C. campestris* on *Mikania micrantha*

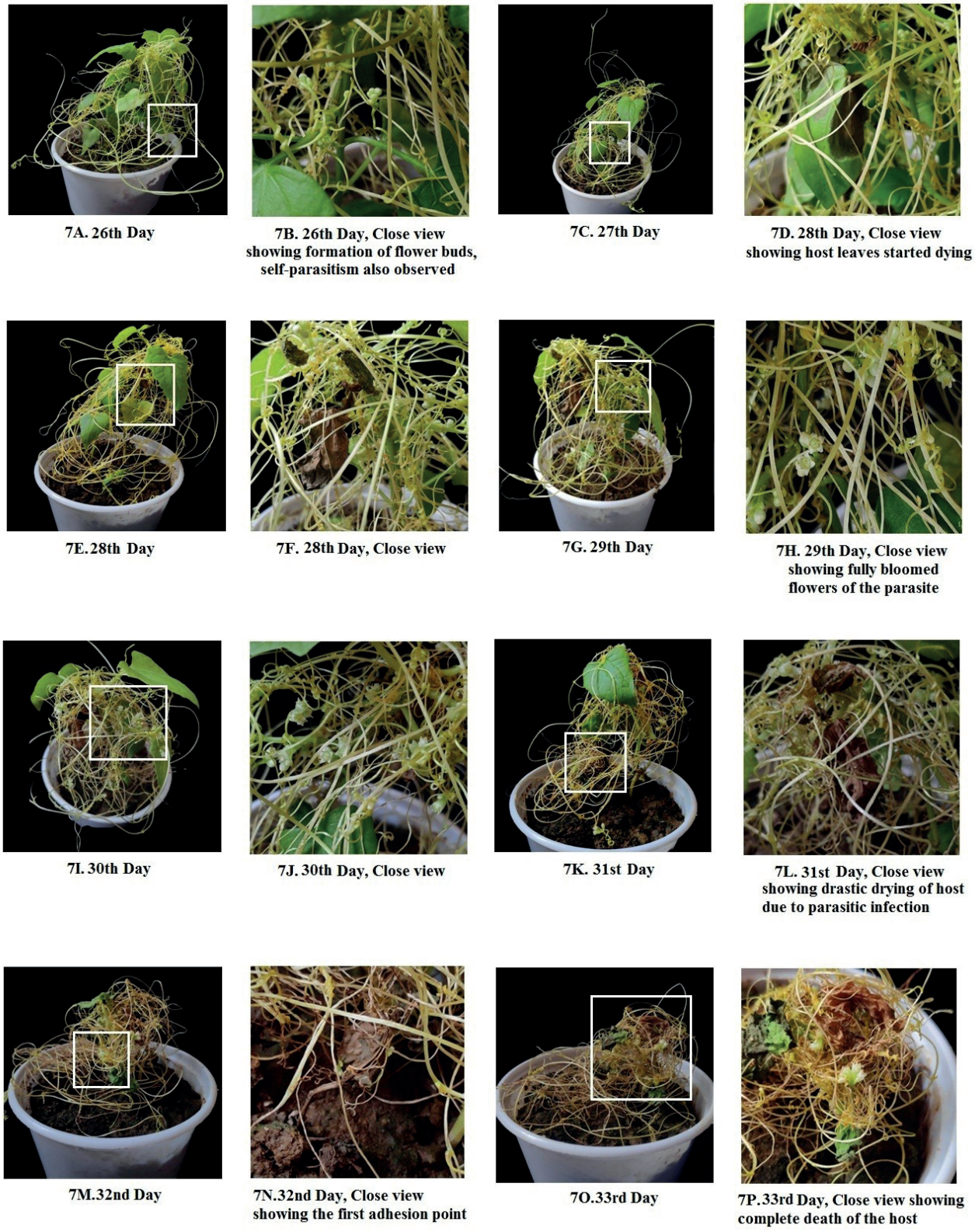

Figure 7(A–P). Experiment on parasitism of *C. campestris* on *Mikania micrantha*

The basal portion starts dying from 4th day onwards from germination. This part does not undergo mitotic division and growth occurs through swelling of cell; this degeneration occurs through programmed cell death to provide Carbon source for the growth of the shoot of the parasite (Sherman et al., 2003; Sherman et al., 2008).

It is interesting to note that after successful shifting, the seedling started to move towards the host in an arc-shaped irregular movement (Lyshede, 1985).

From the observation it was found that the parasite cannot form haustoria without coiling around the host. Dodders (*Cuscuta* species) must have to coil the host before formation of haustoria; that coiled portion also determines the haustorial number (Kelly, 1988).

The seedling after reaching the host, starts coiling in counter-clockwise direction (Kuijt, 1969; Lyshede 1985; Dawson et al., 1994).

The parasitic plant *C. campestris* shows self parasitism also (Fig. 7B). It forms haustorial connections in different stems of the parasite by coiling in counter-clockwise motion (Audus, 1939; Lackey, 1946; Pizzolongo, 1963, etc.)

After extensive survey over more than 1 year, we found that the parasite shows a wide range of host for nutrient absorption. This parasite even infects monocotyledonous plants. According to Dawson et al. (1994), *Cuscuta* species are unable to infect the monocotyledonous plants. But the present study shows 9 species belong to the monocotyledonous group. For confirmation, petiolar anatomy of infected portions of *Colocasia eculenta* (Fig. 2a), *Commelina benghalensis* (Fig. 2c), and foliar anatomy of *Cynodon dactylon* of Poaceae (Fig 2d) were studied under microscope.

The effect of the parasite on crop and weed species is devastating. According to *Cuscuta* has extremely wide host range and after successful infection in primary host, this parasite attacks its secondary hosts for more nutrient requirements (Gaertner, 1950; Kuijt, 1969).

According to, Cooke and Black (1987), grasses may be acting like hosts but there is no penetration of haustoria. But after dissecting the infected leaf of *Cynodon dactylon* (Fig. 2d), we found proper haustorial connections that have found to penetrate upto the deeper ground tissue portion.

This experiment shows the aggressiveness of the *C. campestris* and its quick adaptability in minimal environmental conditions. This parasite is a threat to the native flora as well as the commercially important plants as it can infect very easily due to its diverse host range as well as its weedy nature.

4. Conclusion

Cuscuta campestris is an invasive obligate parasite which is going to bring a devastating threat to the native flora of Assam. It was earlier not recorded as it shows many similarities with the already recorded species *C. reflexa*. From the anatomical studies we found that the haustorium penetrates deep down to the vascular bundle. This severely damages the host anatomy and reduces its quality, disease resistant capacity and leads to death of the host. Assam is an agricultural state. This invasive parasite is going to harm the economically important crops. This will directly affect the economy of the state as well as of the country too. We should put effort to find a solution to delimit its spreading as soon as possible. The invasion must be controlled before it's too late.

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