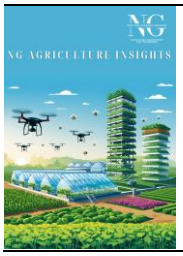

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Mechanism of Host-Parasite Interaction and Integrated Weed Management of Cuscuta in Niger

Rashmi Ranjan Das, Suchismita Tripathy*, Jyoti Rekha Patnaik, Dharani Dhar Pradhan

Department of Agronomy, College of Agriculture, Odisha University of Agriculture & Technology, Bhubaneswar, Odisha

***Corresponding author Email ID:** suchismita.agro@ouat.ac.in

A B S T R A C T

Cuscuta spp. poses a serious constraint to the cultivation of niger in various parts of India. The parasitic weed invades the host vascular tissues through specialized structures called haustoria, and extract water, nutrients and photosynthates; resulting in significant yield loss and potential host mortality. Management of Cuscuta is extremely difficult due to its physiological linkage with the crop. Integration of preventive, mechanical, chemical and biological methods offer a sustainable way for minimizing dodder infestation and enhancing the productivity of niger. Therefore, it is necessary to understand the host-parasite interaction and critical stages of parasite establishment for developing efficient and eco-friendly management strategies.

Keywords: Host-parasite interaction, Parasitic weed, Integrated weed management

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1. INTRODUCTION

Niger [*Guizotia abyssinica* (L.f.) Cass] is grown as a minor oilseed crop primarily in the tribal belt of India. Cuscuta is an annual obligate holo-stem parasitic angiosperm which belongs to the family Convolvulaceae. It acts as a 'Super-sink' counteracting the host's sink to absorb nutritional elements like water, minerals, amino acids, photo-assimilates etc. and adversely affects the growth and development of its host. The parasite completes its lifecycle before the host which results in premature mortality of the parasitized crop and leads to crop damage and reduction in plant population and yield. Among 200 species found worldwide, two species i.e. *Cuscuta chinensis* & *Cuscuta campestris* are found to dominate niger growing tracts. In India, as well as in Odisha, *Cuscuta spp.* possesses a major threat to niger production in some endemic pockets especially in rice fallow areas, causing yield losses up to 60-65% (Tosh et al., 1977).

2. BIOLOGY OF CUSCUTA & ITS DISPERSAL

Convolvulaceae is a family of autotrophic plants, with an exception of Cuscuta as a parasitic Genus. Cuscuta is a wiry weed & is devoid of functional roots, leaves and chlorophyll pigments. Its golden yellow colour is due to presence of carotenoid pigments and it cannot perform photosynthesis expect a few species which display residual photosynthesis. Hence, it completely depends on the host for nutrition. It has very small and bell-shaped; white/cream/yellow/pink flowers arranged in tight clusters. It produces tiny reddish brown- or grey-coloured seeds in a capsule. Cuscuta mainly reproduces by seeds. Its seed has a hard seed coat and can remain dormant for years. The seeds are dispersed

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by means of contaminated crop seeds, machinery, irrigation water, movement of animals and human activities. Cuscuta also possesses the ability for vegetative regeneration, which makes it difficult to control.

Figure 1. Niger infested with *Cuscuta spp*

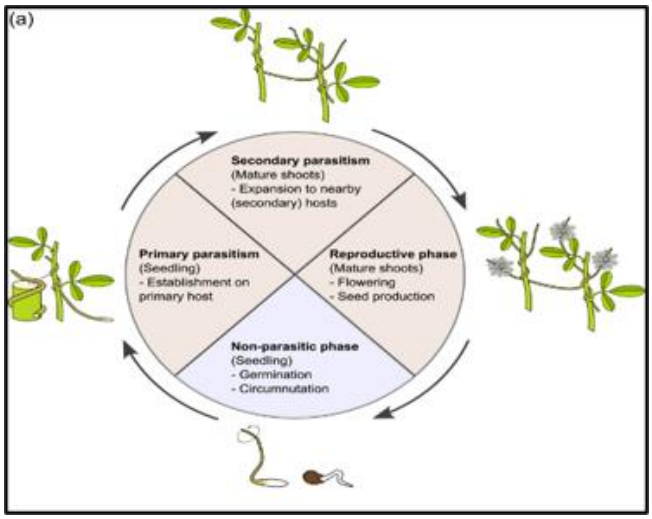

Figure 2. Lifecycle of Dodder (Bawin & Krause, 2024)

3. MECHANISM OF HOST-PARASITE INTERACTION

3.1 Germination and host recognition phase:

Cuscuta seeds germinate independently without any external stimulus from its host; favourable conditions such as adequate soil moisture and temperature promote germination of Cuscuta. Cuscuta seeds have large food reserves sufficient enough to allow the radicle to grow, while finding its host. Germinating Cuscuta seedlings cannot survive for a prolonged period (more than 8 days) solely depending on seed reserves & usually attach to its host which are within 3-4 cm from the point of emergence, otherwise die of starvation. Each seedling emerges as a wiry plumule, straightens out, rotates anticlockwise and locate suitable host either by direct physical contact or by recognizing the light-stimuli (i.e. blue and far-red wavelengths) transmitted through the leaves or by air-borne organic volatile compounds released as chemo-attractants by the host.

3.2 Attachment phase:

After getting attached with the host, the parasitic root undergoes complete senescence. This physical contact between the parasite and the host triggers the differentiation of epidermal and parenchymatous cells into a secondary meristem, leading to the development of pre-haustoria, also known as an 'adhesive sink' or 'upper haustoria'. These pre-haustoria cells secrete certain adhesive substances like pectin and polysaccharides, which strengthens the attachment. In response, the host plant produces arabinogalactan-protein (AGPs) that further supports adhesion at the interface.

3.3 Penetration phase:

Post-attachment, pre-haustoria undergo further development to form 'parasitic haustoria' or 'lower haustoria' and invade the host cell through a fissure aided by the degradation of host cell wall due to secretion of hydrolytic enzymes (i.e. methyl esterases) or a complex of lytic enzymes such as pectinases and cellulases. The frontal cells of haustoria forms a 'searching hyphae' to reach the vascular bundles of host (i.e. xylem & phloem cells). Later, the xylem parenchyma of host and parasite fuse to form a continuous xylem tube from the host to the parasite for the supply of water, nutrients, photo-assimilates, and hormones etc. Dodder forms a continuous symplastic system with host & exchanges macromolecules such as proteins, nucleic acids (mRNAs) including pathogens like viruses and phytoplasmas in a bi-directional manner.

3.4 Physiological changes and impact on host:

Infected niger plants often show reduced photosynthetic rates, hormonal imbalances, depletion of nutrients, water and susceptibility to abiotic and other biotic stresses.

4. INTEGRATED WEED MANAGEMENT

Complete control of *Cuscuta* is difficult to achieve due to its strong physical dormancy, broad host range, persistent seed bank, resistance to herbicides and capacity to propagate by both seed and vegetative structures. An integrated management approach combining prevention, targeted mechanical removal, selective chemical application and appropriate biological methods is a sustainable way for long term effect.

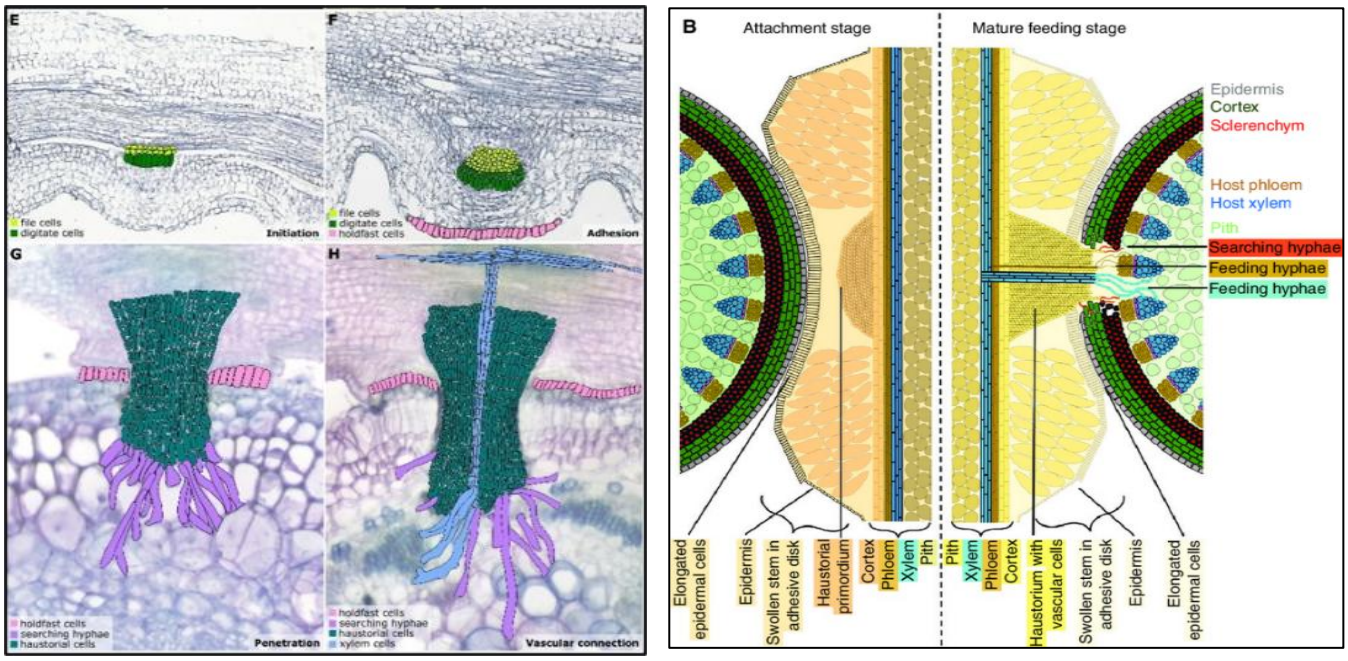

Figure 3. Different phases of host invasion by Dodder (Jhu & Sinha, 2022; Balios et al., 2024)

Table 1. Changes in physiological parameters due to parasitism and its effect on the host

Physiological Parameters	Changes due to Parasitism	Effect on Host (Niger)
Photosynthesis	Reduces	Yellowing; low biomass and dry matter production
Nutrient content	Reduces	Stunted growth
Water status	Water potential & relative water content reduces	Wilting
Hormones	ABA & Ethylene increases; Cytokinin & Gibberellin decreases	Early senescence and reduced growth
ROS	Increases	Cell damage
C/N metabolism	Decreases	Weak seed formation

4.1. Cultural control:

a. Deep ploughing of infested fields before sowing.
b. Cleaning of farm implements.
c. Restricted grazing of animals to infested areas.
d. Use of Cuscuta-free crop seeds.
e. Crop rotation with non-host crops like crops belong to the grass family.
f. Use of Cuscuta-tolerant or resistant varieties.
g. Niger seeds contaminated with Cuscuta should be sieved through a 1mm mesh size sieve and treated with 10% brine solution before sowing.

4.2. Mechanical control:

a. Hand pulling and cutting of Cuscuta vines before flowering and seed setting is the simplest and most effective control of Cuscuta.

4.3. Physical control:

a. Treatment of seed packages with dry heat up to 120^{o} C reduce the viability of Cuscuta without affecting the crop seeds.

4.4. Chemical control:

a. Pre-sowing application of Fluchloralin 1 kg a.i./ha.
b. Pre-emergence application of Pendimethalin 1 kg a.i./ha.
c. Application of Pronamide 4-5 kg a.i./ha, 15 days after the emergence of Cuscuta controls the infestation.

4.5. Biological control:

a. Application of LUBAO 2 (*Colletotrichum gloeosporoidae* f.sp. cuscutae)
b. Release of Cuscuta midge (*Melanagromyza Cuscuta*) in which its larvae bore into the tissues disrupting the parasites vascular system.
c. Release of Gall-forming weevils (*Smicronyx madaranus*) as an epiparasite on Cuscuta.

5. CONCLUSION

The parasitic relationship between niger and dodder represents a complex bio-chemical interaction involving a sequence of events, including host recognition, attachment, haustoria development, penetration of host tissues and establishment of vascular connections which adversely impacts the crop productivity. The physiological link between the host and the parasite makes it difficult to control the weed without damaging the crop. Effective management of dodder in niger cannot rely on a single control measure because of its prolific seed production, long-term seed viability and ability for vegetative propagation. An integrated weed management approach combining preventive measures, suitable cultural practices and need-based herbicide application offer greater potential for reducing infestation and limiting seed-bank replenishment. Future management strategies should emphasize the integration of agronomic practices with advances in host resistance, biological control, precision weed management and environmentally safer herbicide technologies. Thus, integrating knowledge of the biology and host–parasite interaction of dodder with timely and ecologically sound weed-management practices is crucial for sustaining niger productivity and minimizing the long-term impact of this destructive parasitic weed.

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