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Physiological and Biochemical Changes in Certain Angiosperm Plants in Reference to Host- Parasite (*Cuscuta Spp*) Interaction: An Overview

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As compared with plant–microbe interaction, little is identified about the interaction of parasitic plants with their hosts. Therefore, the present overview has been aimed to provide certain cues to researchers working to explore interactions between angiospermic parasites like *Cuscuta* and their hosts in view of development of platform for advancement in agronomic management. *Cuscuta* plants belonging to Cuscutaceae family comprise about 200 species, all of which survive as stem holoparasites on other plants. *Cuscuta spp.* possesses neither roots nor fully expanded leaves and the vegetative portion appears to be a stem only. The parasite winds around host plants and penetrates stems via haustoria, forming direct connections to the vascular bundles of their hosts to withdraw water, carbohydrates, and other solutes. Transpiration is a key process regulating solute transfer from host to parasite. The haustorium appears to play a role in regulating solute composition, and thus angiosperm plants are badly affected by certain plant parasites like *Cuscuta spp*. Upon infection by host plants, certain physiological and biochemical changes occur, affecting the quality and quantity of yield from angiosperm plants. Besides susceptible hosts, a few plants exhibit an active resistance against infestation by *Cuscuta* spp. For example, cultivated tomato (*Solanum lycopersicum*) fends off *Cuscuta reflexa* by means of a hypersensitive-type response occurring in the early penetration phase. Host responses to infection are comprehensively reviewed focusing on angiosperm plants in reference to host- parasite (*Cuscuta spp.*) interaction. It is concluded that competition for water and solutes are unlikely to play a major role in determining reduction in host productivity as a consequence of metabolic incompatibility, suggested to be the major cause of this happening. Nevertheless, this article may provide new insights into developing biochemical strategies for overcoming agricultural perturbation of crop yield.

Key words: Agricultural perturbation; angiosperm plants; *Cuscuta spp*, host- parasite interaction; haustoria

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INTRODUCTION

Thread-like parasitic plants, *Cuscuta*, usually considered as dodders, reflect little resemblance to their photoautotrophic relatives. The genus has been noticed to develop gradually within the Convolvulaceae in the order Solanales and includes nearly 200 species of obligate shoot holoparasitic plants (Garcia et al., 2014). *Cuscuta* is divided into the three subgenera, namely, *Monogynella*, *Cuscuta* and Grammica. Whilst species of Monogynella characteristically have thick stems, the other two subgenera include more delicate species (Iqbal et al., 2014).

Species of *Cuscuta* adversely affect important crops (e.g. alfalfa and tomato) and express severe problems to agriculture as they result in downgrading crop yields (Aly, 2007). Upon development, *Cuscuta* seedlings appear without cotyledons or leaves and with a reduced root-like structure, which rapidly degenerates (Sherman et al., 2008). A few species species of *Cuscuta* are obviously green e.g. *C. reflexa*, reflecting photosynthetic activity. Nevertheless, even in these relatively green species the rate of carbohydrate synthesis is rather low to sustain the parasite (van der Kooij et al., 2000). Thus, for enabling to complete its life cycle, freshly germinated seedlings must quickly locate, adhere and infect a vulnerable host plant. In the later stages of contamination, tip-growing cells called searching hyphae stick out from the main haustorium and grow in search of the vascular tissues of the susceptible host.

In a fully developed feeding haustorium of *C. reflexa* on its vulnerable host *P. zonale*, the xylem viaduct between the two species is evidently visible. Furthermore, plasmodesmata have been noticed between host cells and developing parasite hyphae (Vaughan, 2003; Birschwilks et al., 2006, 2007). This happening reveals the evidence of interspecific symplastic connections being established. When it reaches to the range of host species parasitized, certain *Cuscuta* species are very common that can successfully infect a large number of different host plants, whilst others are confined to only a single host species. The parasite seems to approach dicotyledonous plants, as monocotyledonous plants are barely infected. Grasses, especially, are shown to be in but very few cases, immune to *Cuscuta* (Vaughan, 2003) . Notwithstanding, there are also dicotyledonous species, which display resistant mechanisms against *Cuscuta* attacks (Kaiser et al., 2015). Certain physiological and biochemical alterations in angiospermic plants as a consequence of *Cuscuta* infection have been overviewed under following headings:

Plant Responses to Invasion: Considering that plants possess systems to identify and act against attacks by other plant pathogens (Boller and Felix, 2009) , it appears improbable that the intruding risk of the haustorium should go on unnoticed. As such, the zonale, display no clear defence reactions when infected by *C. reflexa* is quite remarkable. The haustoria of *C. reflexa* were observed to invade the tropical liana *Ancistrocladus heyneanus,* but eventually deteriorated as a response to the production of pathogen repellents by the host. Poinsettia *(Euphorbia pulcherrima)* responds to haustoria of *C. reflexa* and *C. japonica* by producing localized bark projections, which force out the infection organs (Christensen et al., 2003). Anyhow, the host has been demarcated as partially incompatible as the parasite could bear haustorium rejections by developing new infection sites. The cultivated tomato *Solanum lycopersicum* has been shown to be resistant to infection by *C. reflexa,* whilst the wild tomato *Solanum pennellii* is susceptible (Hegenauer et al., 2016); these closely concerned species provide an excellent system for working on host-parasite interactions.

Expression of genes encoding a cell wall enzyme and an aquaporin have been associated with the hypersensitive- type response of this tomato against *C. reflexa* (Werner, 2001; Albert et al., 2004). The obstacle of *S. lycopersicum* appears to be specific against *C. reflexa* as many other species inclusive of *Cuscuta pentagona* are able to successfully infect this plant species. However, *S. lycopersicum* responds with strong inductions of the defense-concerned plant hormones, namely, jasmonic acid and salicylic acid as a consequence of being contagious by *C. pentagon* (Runyon et al., 2010). Both hormones are known to play pivotal roles in plant immunity (Pieterse et al., 2012; Shigenaga and Argueso, 2016). Infection by *C. reflexa* also induces release of Ca^{2+}, a major player in signal transduction pathways, in the resistant tomato (Albert et al., 2010).

Recently, it was reported that the pattern recognition receptor, namely, *Cuscuta* Receptor 1 of *S. lyopersicum* finds out a small peptide factor from *C. reflexa* and commences the above mentioned defense responses (Hegenauer et al., 2016). This reveals that plants can sense for *Cuscuta* much in the same way as they do accept other plant pathogens (Malinovsky et al., 2014; Mitsumasu et al., 2015).

Invasion of Host Tissues: The unilineal inflamentation of the parasite's stem facing the host surface reflects the initiation of haustorium development. *Cuscuta* epidermal cells then secrete a cementing substance that secures the attachment of parasite to host (Lee, 2008). Proper adherence to the host surface seems to be essential for intrusion as the parasite also induces the host to produce substances that further augments the adhesion force (Albert et al., 2006). Activity of a cysteine protease from *C. reflexa* has been observed to be essential for flourishing host infection, proposed by degrading host proteins (Bleischwitz et al., 2010). Interestingly, the prohibition of a similar cysteine protease in the obligate root parasite *Phelipanche aegyptiaca* has also been noticed to reduce infection rates (Rehker et al., 2012). A shoot meristemless-like protein is essential to host infection by *C. pentagona* as gene silencing by RNA interference distorts the growth and development of the parasite haustorium (Alakonya et al., 2012). Presumably involved in directing growth of searching hyphae, the exact function of this protein remains obscure. Recently, transcriptome analyses have corresponded the high expression of genes encoding products concerning with transport activity and cell wall with haustoria development in both *Orobancheae* (Orobanchaceae) and *Cuscuta* (Convolvulaceae) (Ranjan et al., 2014; Ikeue et al., 2015; Yang et al., 2015). The enhanced production of transporters is consistent with the parasite preparing to feed on its host.

Plant Cell Wall: One may identify three layers in a plant cell wall: (i) The middle lamella forms the fixative boundary between cell walls of adjoining cells; (ii) The primary wall is a strong but extensible layer continuously synthesized and transformed by growing cells; Some cell types (e.g. xylem cells) deposit a (iii) secondary wall between their primary wall and the plasma membrane to give further strength and rigidity after growth cessation (Popper, 2008). Cellulose is the principle structural component of plant cell walls. This polysaccharide is synthesized by large enzyme complexes at the plasma membrane and consists of long linear chains of β-(1→4)-linked glucose packed tightly into microfibrils (Popper, 2008). Cellulose microfibrils are stiff rods of enormous mechanical strength that contribute structural stability to the cell wall when cross-linked by other wall polysaccharides.

The term hemicellulose encompasses non-cellulosic polysaccharides with β-(1→4)-linked backbones that are often extensively branched. This includes xyloglucan, xylan, mannan and mixed-linkage glucan (which have β-(1→3)-linkages interspersed at regular intervals within their β-(1→4)-linked backbone) (Scheller and Ulvskov, 2010). Hemicelluloses are synthesized in the Golgi and secreted into the apoplast where their main role is to strengthen the cell wall by interacting with cellulose. Pectin is a heterogeneous group of complex cell wall polysaccharides that are rich in galacturonic acid. The three main types of pectin are homogalacturonan, rhamnogalacturonan and rhamnogalacturonan-I (Willats et al., 2001). Pectic polysaccharides form a gel-like matrix between cellulose microfibrils, associated with several different functions. In the middle lamellae of dicotyledonous plants, pectins are proposed to facilitate adhesion between adjacent cells (Jarvis et al., 2003).

Classically, the primary cell wall of dicotyledonous plants is recognized as a load-bearing network of xyloglucan-coated cellulose microfibrils embedded in a pectin matrix. However, increasing verification argues that linkages exist between pectins and other cell wall components including cellulose and xyloglucan (Popper and Fry, 2008; Chebli and Geitmann, 2017). These networks of polysaccharides make up a complex matrix that allows plant cells to keep high turgor pressures and thus enables plants to stand tall to harvest sunlight efficiently. Although, as plant growth and development require cell division, expansion and differentiation, plant cells are supposed to be able to control and modify the mechanical properties of their walls.

Cell Wall Modifiers: In fill out cells, new wall polymers are secreted into the cell wall to avert thinning as the cell surface increases. However, the structure, strength and flexibility of the primary cell wall is not only decided by what components are synthesized and deposited into the apoplast. Various proteins regulate plant growth and development by acting on the polysaccharides, which build up the cell wall. Some of these are glycoside hydrolases that develop cell wall loosening by splitting more or less specific polysaccharides. Others split one polysaccharide chain and graft it onto another (transglycosylation) and can thus facilitate either loosening or the reversal strengthening of the cell wall (Frankova and Fry, 2013). The xyloglucan endotransglucosylases/hydrolases (XTHs) modify wall strength by transglycosylating or hydrolytically cleaving the hemicellulose xyloglucan, respectively, termed xyloglucan endotransglucosylation (XET) and xyloglucan endohydrolysis (Rose et al., 2002). Pectins are uploaded into the cell wall in a highly methyl-esterified state. The de-esterification of pectins by pectin methyl esterases makes the polysaccharide extra prone to degradation by pectate lyases and polygalacturonases (Wakabayashi et al., 2003). Though, as de-esterification of pectins also facilitates cross-linking and gel formation, pectin methyl esterases can be promoters of both cell wall loosening and strengthening (Willats et al., 2001; Chebli and Geitmann, 2017). Expansins are proteins that induce wall loosening without exhibiting enzymatic activity, probably by disrupting hydrogen bonds between wall polysaccharides (Cosgrove, 2005). Whereas plants modify their own walls to regulate growth and development, plant tissue invaders have been shown to employ cell wall modifiers to achieve access across the cell wall.

Genetic Transformation of *Cuscuta*: The ability to knock out specific genes in an organism is a potential tool for investigating gene function. A protocol for the transient transformation of *C. reflexa* using a biolistic particle delivery system has been successfully developed by Cosgrove (2005). This system has been observed to take helium pressure to shoot DNA-coated microcarriers (e.g. gold) into cells where, if reaching any of the DNA-containing nucleus, mitochondria and plastids, the transgene may be incorporated into the respective genome or expressed transiently from a plasmid vector. Evidently, gold particles coated with a declaration plasmid encoding a *Discosoma* sp. red fluorescent protein (dsRed) was bombarded onto the surface of *C. reflexa* stem pieces. The presence of polyphenol oxidases in *Cuscuta* results in the production of brown pigments in tissues damage by the microcarriers (Cosgrove, 2005). Protocols for *Agrobacterium*-mediated transformation of *Cuscuta* calli have been reported earlier' (Borsics et al., 2002; Anami et al., 2013; Svubova and Blehova, 2013), but none of these were able to revive genetically modified *Cuscuta* plants. An important facet of stable transformation is the use of proper selective agents to only allow the proliferation of resistance-acquired transformed cells. Callus cultures of *C. reflexa* were enlarged on Murashige and Skoog medium supplemented with sucrose (50 g/l), the cytokinin kinetin (3 mg/l), the auxin 1-Naphthaleneacetic acid (3 mg/l) and gibberellic acid (0.1 mg/l). A 5 µg/ml concentration of the protein synthesis-fend hygromycin B killed *C. reflexa* calli within a week. Bombarded tissues of *Cuscuta* would require more time for treatment recovery and genomic unification to establish a stable expression of transgenes, probably enabling survival and proliferation on the selective medium. Therefore, in order to find a suitable concentration, which might allow transformed cells this recuperation time, the growth of callus on medium containing 0.2 and 1 µg/ml hygromycin B, was tested. Both 0.2 and 1 µg/ml hygromycin B diminished the growth of *C. reflexa* calli. After 3 weeks, the callus on growth medium with 1 µg/ml hygromycin B point signs of cell death, which were even more pronounced after 8 weeks. As reported earlier by Das et al. (2011), equal concentrations of auxin and cytokinin start regeneration of *C. reflexa* shoots from callus. . This demonstrates the possibility to selectively regenerate transgenic *Cuscuta* if transgenes encoding hygromycin-resistance can be stably expressed in the parasitic plant. Genomic integration and retention of transgenes are challenges left to tackle in the continuing efforts to establish a protocol for the stable transformation of the parasitic plant *Cuscuta*.

Biochemical Defense Mechanism in Rapeseed-Mustard Genotypes against Alternaria blight Disease: Biochemical defense response in rapeseed-mustard genotypes has been observed upon infection with *Alternaria brassicae* (Berk.) Sacc. causing blight at different growth stage (Mathpal et al., 2011). Three genotypes viz.*Brassica juncea* cv. Varuna (susceptible), *B. juncea* cv. PAB-9534 (moderately resistant) and *B. alba* (tolerant) were selected. Results revealed all the genotypes to show variable disease severity. It was observed that in all stages of pathogen infection, disease severity and characteristic symptoms were more prominent insusceptible genotype than the other two. The biochemical analysis of leaves of different varieties of mustard revealed that total phenol, o-dihydroxy phenol, total sugar, reducing sugar, chlorophyll content and flavonol contents were more in resistant genotype (*B. alba*) than others. With progress of infection, total phenol, o-dihydroxy phenol and protein content increased in all three genotypes while the chlorophyll, total sugar, reducing sugar and flavonol content decreased. These results indicated that factors conditioning the host response to *A. brassicae* might be the outcome of complex biochemical changes operated in hostgenotypes (Mathpal et al., 2011).

Yield and Yield Attributes of Rapeseed-Mustard (*Brassica*) Genotypes Grown under Late Sown Condition: A field experiment was conducted at the Central Research Station of BARI, Gazipur, India for two consecutive years 2010-11 and 2011-12 with 30 varieties/ genotypes of rapeseed-mustard under three dates of sowing viz., 25 November, 5 December, and 15 December to determine changes in crop phenology, growth and yield of mustard genotypes under late sown condition when the crop faced high temperature (Alam et al., 2014). Days to flowering and maturity were different at different planting times. Date of sowing significantly influenced plant height, siliquae/plant, seeds/siliqua, seed yield, and oil content of seed in both the years. The highest seed yield (1310 and 1535 kg/ha) was obtained from the first planting (25 November) in both the years, which was significantly different from two other dates of sowing. Yield and yield attributes of different varieties varied significantly. Among the varieties, BARI Sarisha-16 of *Brassica juncea* gave significantly the highest seed yield (1495 and 1415 kg/ha), which was statistically identical to BJDH-11, BJDH-12, BJDH-05, BJDH-20, and BARI Sarisha-6 and significantly different from all other varieties (Alam et al., 2014). Interaction effect of variety and sowing date significantly influenced plant height, number of siliquaeper plant, number of seeds per siliqua, seed yield and strover yield. The highest seed yield (1758 and 1825 kg/ha) were recorded from BJDH-11 and BARI Sarisha-16 of *Brassica juncea* at 25 November planting and BJDH-11 produced the highest yield at 15 December in both the years. The maximum strover yield (3758 and 3825 kg/ha) were obtained from BJDH-11 and BARI Sarisha-16 of Brassica junceaat 25 November planting during 2010-11 and 2011-12. The highest oil content of seeds (44.4 % and 45.9%) was obtained from the seed of BARI Sarisha-6 and BARI Sarisha-14 at 25 November planting in both the years (Alam et al., 2014).

Advances in Agronomic Management of Indian Mustard (*Brassica juncea* (L.) Czernj. Cosson: India is the fourth largest oilseed economy in the world. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6% in the total oilseeds production and ranks second after groundnut sharing 27.8% in the India's oilseed economy. The mustard growing areas in India are experiencing the vast diversity in the agro climatic conditions and different species of rapeseed-mustard are grown in some or other part of the country (Shekhawat et al., 2012). Under marginal resource situation, cultivation of rapeseed-mustard becomes less remunerative to the farmers. This results in a big gap between requirement and production of mustard in India. Therefore site-specific nutrient management through soil-test recommendation based technique should be adopted to improve upon the existing yield levels obtained at farmers field. Effective management of natural resources, integrated approach to plant-water, nutrient and pest management and extension of rapeseed-mustard cultivation to newer areas under different cropping systems can play a key role in further increasing and stabilizing the productivity and production of rapeseed-mustard (Shekhawat et al., 2012).

Parasitic Plants of the Genus *Cuscuta* and their Interaction with Susceptible and Resistant Host Plants: By comparison with plant-microbe interaction, little is known about the interaction of parasitic plants with their hosts. Plants of the genus *Cuscuta* belong to the family of Cuscutaceae and comprise about 200 species, all of which live as stem holoparasites on other plants (Das et al., 2011; Mathpal et al., 2011). *Cuscuta spp.* possesses neither roots nor fully expanded leaves and the vegetative portion appears to be a stem only. The parasite winds around plants and penetrates the host stems via haustoria, forming direct connections to the vascular bundles of their hosts to withdraw water, carbohydrates, and other solutes. Besides susceptible hosts, a few plants exist that exhibit an active resistance against infestation by *Cuscuta spp.* For example, cultivated tomato (Solanum lycopersicum) fends off *Cuscuta reflexa* by means of a hypersensitive-type response occurring in the early penetration phase. This report on the plant-plant dialog between *Cuscuta spp.* and its host plants focuses on the incompatible interaction of *C. reflexa* with tomato (Mathpal et al., 2011).

Cell Wall Composition of Parasitic Dodder (*Cuscuta reflexa*) and its Hosts: A Priori Differences and Induced Alterations: Host plant penetration is the gateway to survival for holoparasitic *Cuscuta* and requires host cell wall degradation. Compositional differences of cell walls may explain why some hosts are amenable to such degradation while others can resist infection (Borsics et al., 2002). Antibody-based techniques for comprehensive profiling of cell wall epitopes and cell wall-modifying enzymes were applied to several susceptible hosts and a resistant host of *Cuscuta reflexa* and to the parasite itself. Infected tissue of Pelargonium zonale were shown to contain high concentrations of de-esterified homogalacturonans in the cell walls, particularly adjacent to the parasite's haustoria. High pectinolytic activity in haustorial extracts and high expression levels of pectate lyase genes suggest that the parasite contributes directly to wall remodeling. Mannan and xylan concentrations were low in P.Â zonale and in five susceptible tomato introgression lines, but high in the resistant *Solanum lycopersicum* cv M82, and in *C. reflexa* itself. Knowledge of the composition of resistant host cell walls and the parasite's own cell walls is useful in developing strategies to prevent infection by parasitic plants (Borsics et al., 2002).

Detection of the Angiosperm Parasite, *Cuscuta reflexa* by a Tomato Cell Surface Receptor: Parasitic plants are a constraint on agriculture worldwide. *Cuscuta reflexa* is a stem holoparasite that infests most dicotyledonous plants. One exception is tomato, which is resistant to *C. reflexa* (Hegenauer et al., 2016). Researchers discovered that tomato responds to a small peptide factor occurring in *Cuscuta spp.* with immune responses typically activated after perception of microbe-associated molecular patterns. Cell surface receptor-like protein CUSCUTA RECEPTOR 1 (CuRe1) is essential for the perception of this parasite-associated molecular pattern. CuRe1 is sufficient to confer responsiveness to the *Cuscuta* factor and increased resistance to parasitic *C. reflexa* when heterologously expressed in otherwise susceptible host plants. These findings reveal that plants recognize parasitic plants in a manner similar to perception of microbial pathogens (Hegenauer et al., 2016).

Identification of Tomato Initiation Lines with Increased Susceptibility or Resistance to Infection by Angiosperm Parasitic Extremely Large Dodder (*Cuscuta reflexa*): The parasitic flowering plant genus *Cuscuta* (dodder) is a parasitic weed, which infects many economically cruciält crops. Once it winds around the shoots of potential host plants and initiates the development of penetration organs, called haustoria, only a few plant species have been shown to deploy effective defense mechanisms to ward off *Cuscuta* parasitization (Kaiser et al., 2015). However, a notable exception is *Solanum lycopersicum* (tomato), which exhibits a local hypersensitive reaction when attacked by giant dodder (*Cuscuta reflexa*). Interestingly, the closely related wild desert tomato, *Solanum pennellii*, is unable to stop the penetration of its tissue by the *C. reflexa* haustoria. In this study, researchers observed that grafting a *S. pennellii* scion onto the rootstock of the resistant *S. lycopersicum* did not change the susceptibility phenotype of *S. pennellii*. This indicates that hormones, or other mobile substances, produced by *S. lycopersicum* do not induce a defense reaction in the susceptible tissue. Screening of a population of introgression lines harboring chromosome fragments from *S. pennellii* in the genome of the recurrent parent *S. lycopersicum*, revealed that most lines exhibit the same defense reaction as revealed by the *S. lycopersicum* parental line. Though, several lines showed different responses and exhibited either susceptibility, or cell death, which extended considerably beyond the infection site. These lines can be valuable for the future identification of key loci involved in the perception of, and resistance to, *C. reflexa* and for creating strategies to enhance resistance to infection in crop species (Kaiser et al., 2015).

Impact of Infection by *Cuscuta reflexa* Roxb on Androgen-induced alopecia: Alopecia is a psychologically distressing condition. Androgenetic alopecia, which affects millions of men and women, is an androgen-driven disorder. *Cuscuta reflexa* Roxb is evaluated for hair growth activity in androgen-induced alopecia (Pandir et al., 2008). Petroleum ether extract of *C. reflexa* was successfully studied for its hair growth-promoting activity (Pandir et al., 2008). Alopecia was induced in albino mice through testosterone administration for the period of twenty days. Its inhibition by simultaneous administration of extract was monitored using follicular density, anagen/telogen ratio, and microscopic observation of skin sections. For investigating the mechanism of observed activity, *in vitro* experiments were conducted to study the effect of extract and its major component on activity of 5-alpha-reductase enzyme. Petroleum ether extract of *C. reflexa* exhibited promising hair growth-promoting activity as reflected from follicular density, anagen/telogen ratio, and skin sections. Inhibition of 5-alpha-reductase activity by extract and isolate indicates that the extract reversed androgen-induced alopecia by inhibiting conversion of testosterone to dihydrotestosterone. The petroleum ether extract of C. *reflexa* and its isolate has been shown to be useful in treatment of androgen-induced alopecia by inhibiting the enzyme 5-alpha-reductase (Pandir et al., 2008).

Evidence for Abscisic Acid Biosynthesis in *Cuscuta reflexa*, A Parasitic Plant Lacking Neoxanthin: Abscisic acid (ABA) is a plant hormone observed in all higher plants; it plays a pivotal role in seed dormancy, embryo development, and adaptation to environmental stresses, most remarkably drought. The regulatory step in ABA synthesis is the cleavage reaction of a 9-cis-epoxy-carotenoid catalyzed by the 9-cis-epoxy-carotenoid dioxygenases (NCEDs). The parasitic angiosperm *Cuscuta reflexa* lacks neoxanthin, one of the common precursors of ABA in all higher plants (Qin et al, 2008). Therefore, still a brainstorming concern of *C. reflexa* of being capable of synthesizing ABA, or does it acquire ABA from its host plants? Stem tips of *C. reflexa* were cultured *in vitro* and found to accumulate ABA in the absence of host plants (Qin et al, 2008), and demonstrating that this parasitic plant is capable of synthesizing ABA. Dehydration of detached stem tips caused a big rise in ABA content. Two NCED genes, CrNCED1 and CrNCED2, were cloned from *C. reflexa*. Expression of CrNCEDs was up-regulated significantly by dehydration. *In vitro* enzyme assays with recombinant CrNCED1 protein showed that the protein is able to cleave both 9-cis-violaxanthin and 9'-cis-neoxanthin to give xanthoxin. Therefore, despite the absence of neoxanthin in *C. reflexa*, the biochemical activity of CrNCED1 is similar to that of NCEDs from other higher plants (Qin et al, 2008). These data provide evidence for conservation of the ABA biosynthesis pathway among members of the plant kingdom (Qin et al, 2008).

***Cuscuta reflexa* Invasion Induces Calcium Release in Its Host:** *Cuscuta reflexa* has been reported to induce a variety of reaction in its hosts. Some of these are visual reactions, and it is clear that these morphological changes are preceded by events at the molecular level, where signal transduction is one of the early processes (Albert et al., 2010). Calcium (Ca^{2+}) release is the principal second messenger during signal transduction, and thus it has been studied for monitoring Ca^{2+} spiking in tomato during infection with *C. reflexa*. Bioluminescence in aequorin-expressing tomato was successfully noticed for 48 h after the onset of *Cuscuta* infestation. Signals at the attachment sites were observed from 30 to 48 h. Treatment of aequorin-expressing tomato leaf disks with *Cuscuta* plant extracts suggested that the substance that induced Ca^{2+} release from the host was closely linked to parasitic haustoria (Albert et al., 2010).

Plastidic Genome Conformation and Degradation of Photosynthetic Activity in *Cuscuta*: The genus *Cuscuta* (dodder) has concern with parasitic plants, some species of that appear to be losing the ability to photosynthesize. A molecular phylogeny was constructed using 15 species of *Cuscuta* in order to assess whether changes in photosynthetic ability and alterations in structure of the plastid genome relate to phylogenetic position within the genus (Revill et al., 2005). The molecular phylogeny provides evidence for four major clades within *Cuscuta*. Though DNA blot analysis revealed that *Cuscuta* species have smaller plastid genomes than tobacco, and that plastome size varied remarkably even within one *Cuscuta* clade; dot blot analysis reflected that the dodders possess homologous sequence to 101 genes from the tobacco plastome (Revill et al., 2005). Evidence is provided for significant rates of DNA transfer from plastid to nucleus in *Cuscuta*. Size and structure of *Cuscuta* plastid genomes, as well as photosynthetic ability, appear to vary on its own of position within the phylogeny, probably supporting the hypothesis that within *Cuscuta* photosynthetic capability and organization of the plastid genome are altering in a clumsy fashion (Revill et al., 2005).

Assessment of Total DNA Sequences of Plastidic Genomes of Two Parasitic Plant Species, Namely, *Cuscuta reflexa* and *Cuscuta gronovii*: The holoparasitic plant genus *Cuscuta* comprises species with photosynthetic capacity and functional chloroplasts as well as achlorophyllous and intermediate forms with restricted photosynthetic activity and degenerated chloroplasts (Funk et al., 2007). Previous data reflected significant differences with respect to the plastid genome coding capacity in different *Cuscuta* species, which could correlate with their photosynthetic activity. In order to getting new insights into molecular alterations accompanying the parasitic lifestyle, researchers sequenced the plastid chromosomes of the two species viz. *Cuscuta reflexa* and *Cuscuta* gronovii (Funk et al., 2007). Both species are having the potential of performing photosynthesis, though with varying efficiencies. Together with the plastid genome of *Epifagus virginiana*, an achlorophyllous parasitic plant whose plastid genome has been sequenced, these species represent a series of progression towards complete dependency on the host plant, ranging from reduced levels of photosynthesis in *C. reflexa* to a restricted photosynthetic activity and degenerated chloroplasts in *C. gronovii* to an achlorophyllous state in *E. virginiana* (Funk et al., 2007). The newly sequenced plastid genomes of *C. reflexa* and *C. gronovii* reveal that the chromosome structures are basically very similar to that of non-parasitic plants, though a number of species-specific insertions, deletions and sequence inversions were recognized. Overall, the comparative genomic analysis of plastid DNA from parasitic plants reflects a partiality towards a simplification of the plastidic gene expression (Funk et al., 2007).

CONCLUSION AND FUTURE PERSPECTIVE

Conclusively, studies covered by this review article together entail that there are a number of complications, which are developed as a consequence of angiosperm host- parasite interaction, ultimately badly affecting crop yield (Mishra and Sanwal, 1992, 1994, 1995, 1997; Gibot-Leclerc et al., 2012; Fernández-Aparicio et al., 2016). Never-the-less, certain strategies may be developed based on studies admirably gathered herein, probably be assisting to agricultural field in view of upgrading the biochemical defense mechanism in oil-seed bearing angiospermic plants against parasites like *Cuscuta* revealing advancements in agronomic management, and thus overcoming the concern of qualitative as well as quantitative crop yield in future.

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