

AN ASSESSMENT OF BIOCHEMICAL CHARACTERIZATION OF BIOACTIVE COMPOUNDS FROM ENDOPHYTES OF FAMILY ZYGOPHYLLACEAE WITH SPECIAL REFERENCE TO MEDICINAL PLANT *TRIBULUS TERRESTRIS*: A REVIEW

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ABSTRACT

*Medicinal Plants have been a vigorous source of Phytomedicines. Endophytes are microorganisms that live in host tissues and establish a mutual association. These microbes are excellent source of bioactive compounds. Plants infected with endophytes are generally healthier than endophytes free ones. These endophytes are the potent source of secondary metabolites similar to the plant tissue on which these endophytes are grown. These chemical metabolites of plants can be derived from any part of plant like stem, bark, leaves, flowers, roots, fruits, seeds etc. Synthesis of these compounds increases many folds in association with endophytes. These microbial endophytes reside in host plants without causing any symptoms of infection so they are gaining attention of researchers for research related to these endophytes in many aspects such as in agriculture, medicines, environmental studies etc. In the recent development of research, the medicinally important genus *Tribulus terrestris* has a fewer extent of microbial endophytes specificity. A very limited study has been accessible on bioactive compounds isolated from endophytes and their role in health related benefits. Therefore, this review article presents an assessment and will prominently contribute a knowledge about the endophytes reside in the different genus of family Zygophyllaceae specially *Tribulus terrestris* as a source of bioactive and chemically novel compounds along with various biochemical activities.*

Keywords: *Microbial Endophytes, Symbiotic, Bioactive Compounds, Agriculture, Exploration, Zygophyllaceae, Phytomedicines.*

Introduction

The word endophytes taken from the Greek dictionary endon—within and phyton—plant, as microflora associated in tissues of their host plants. Many diverse group of fungi, bacteria or actinomycetes belong to these endophytes (Sahani and Thakur, 2019; Monnanda *et al.*, 2014). These endosymbionts have been found to be present in vegetative and reproductive parts of the host plant. They are efficiently enter and flourish in the plant tissues and have different type of positive interactions within the plant (Hilarino *et al.*, 2011; Sahani *et al.*, Caruso *et al.*, 2020; Khare *et al.*, 2018). Mostly the relationship between the plant and its endophytes is mutualistic (Goryluk *et al.*, 2009).

These Microbes have strong ability to produce phytochemical substances which are supportive to protect their host plants against several pathogens and microbes. Thus, endophytes are assumed to be an expedient and possible reason of making or enrichment of these novel bioactive compounds for

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pharmaceutical and agronomic purposes (Sahani and Thakur, 2019). They are a reservoir of many imperious chemical compounds such as alkaloids, amines, phenolic compounds and flavonoids, steroids, saponins, quinones, tannins, terpenoids etc.

These secondary metabolites are accompanying with numerous biological actions. Therefore, endophytic microflora is an imperative and annoying source for a lot of valuable medicines (Gouda *et al.*, 2016). Currently broad research is accompanied on isolation and identification of these bacterial and fungal endophytes on a variety of growth medium. Countless therapeutic and curative products were acquired from these microbial endophytes (Sahani *et al.*, 2018).

These bacterial and fungal endophytes are mostly isolated from medicinal plants (Rhoden *et al.*, 2012). Their beneficial symbiotic relationship with their host plant can influence many vital actions and production of secondary chemical substances such as they have a great influence on production of medicinally important compounds, support in stimulating their growth, increasing their acclimatization, act an important role to withstand abiotic and biotic stresses (Jia *et al.*, 2016). These secondary metabolites which were isolated from medicinal plants have many therapeutic values and have unique structural groups (Caruso *et al.*, 2020). These varieties of endophytes boost the resistance of plants many folds pathogens. They produce various phytohormones and other bioactive secondary metabolites, enzymes and therapeutic drugs (Gouda *et al.*, 2016).

Antibiotics manufactured by these endosymbiont are important to prevent establishment of pathogens (Alvin *et al.*, 2013). Importance of these endophytes is also being increased as they synthesize different kinds of metabolites thus increasing crop productivity (Arora *et al.*, 2017). Bacterial endophytes are also known to produce an enzyme ACC deaminase which breaks the ACC which is a precursor of ethylene. They also help in the defence of host plants by the production of antagonistic substances against a variety of pathogens also an incredible source to synthesize nanoparticles (Chaturvedi *et al.*, 2016).

Mycoendophytes are the most creative groups of secondary metabolite producers among endophytes (Sahani and Hemalatha, 2018). Endophytic fungi can produce many phytohormones which are essential in enhancing growth and minimize the harmful effects of abiotic stresses (Khan *et al.*, 2017).

Family Zygophyllaceae consists of 22 genus and 285 species (Beieret *et al.*, 2003; Bellstedtet *et al.*, 2008; Kour *et al.*, 2016). *Tribulus*, *Fagonia*, *Zygophyllum* and *Peganum* are the main genus of this family. Many members are being used as ethno medicinal in traditional and folk medicines (Rates, 2001; Houghton *et al.*, 2007; Ahmed *et al.*, 2020).

The genus *Tribulus* is a plant having medicinal and therapeutic value belonging to the family Zygophyllaceae. It has about 20 species in the world, out of which three species - *Tribulus cistoides*, *Tribulus terrestris*, and *Tribulus alatus*, are found commonly in India (Sahani and Thakur, 2019).

Peganum harmala is a cosmopolitan in nature (Ouzidet *et al.*, 2020). It is a perennial, smooth glassy plant which grows as wild in semiarid conditions, steppe areas and sandy soils (Kour *et al.*, 2016).

Fagonia indica is a small spiny shrub found in arid regions of the world mainly Asia and Africa (Rahman *et al.*, 2017). It is a flowering plant and consists of about 18 species (Amieret *et al.*, 2019). It is a small spiny undershrub with stiff branches often more or less prostrate (Kour *et al.*, 2016).

The genus *Zygophyllum* has 120 species. Many biochemical substances are isolated from this plant which is used in the treatment of many diseases. Therefore, these species could be used as raw materials of primary importance for various pharmaceutical industries (Mohammedi, 2020).

Hence, the plants of the family Zygophyllaceae have a rich treasure of high therapeutic and pharmacological significance and play an important role in medicinal field (Kour *et al.*, 2016).

Table 1: Some Plants of the Family Zygophyllaceae and their Biological Activities

S. No.	Plant name	Part used	Methods/solvents used for screening and extraction	Screened and isolated compounds	Biological properties	References
1	<i>Fagonia spp.</i>	Aerial parts	Methyl alcohol	Phenols, Tannins, Saponins, Flavonoids, and Alkaloids	Antioxidant, Antimicrobial, Allelopathic	El-Amier and Abo Aisha, 2019
		Whole Plant	Ethanol	Carbohydrates, Flavonoids, Tannins and Unsaturated sterols and/or Triterpenes	Hypoglycemic	Mahdy and Shehab, 2015

		Whole Plant	Methanol fractionations: n-hexane fraction , chloroform fraction , ethyl acetate fraction , n-butanol fraction and residual aqueous fraction .	Saponins and Alkaloids	Antimicrobial, Cytotoxic	Rashid <i>et al.</i> , 2013
2	<i>Peganum harmala</i>	Seeds	Methanol	Alkaloids: harmalacidine, harmine ,peganine and vasicinone .	Cytotoxic, Antiproliferative	Lamchouri <i>et al.</i> , 2010
		Leaves	Ethyl acetate, Chloroform, Butanol and Methanol extracts		Antibacterial, Antioxidant, Antiviral	Hayet <i>et al.</i> , 2010
		Seeds	Methanol, Water, Ethyl acetate	polyphenols, Flavonoids and Tannins	Antibacterial, Antioxidant	Khadhret <i>et al.</i> , 2017
3	<i>Tribulus terrestris</i>	Leaf, stem and root	Aqueous acetone and chloroform extracts		Antimicrobial	Sasikala <i>et al.</i> , 2014
		Whole Plant	Ethanol, Methanol, Acetonitrile, hexane		Antibacterial, Cytotoxic, Hypoglycemic	Hussain <i>et al.</i> , 2009
4	<i>Zygophyllum spp.</i>	Aerial Parts		Triterpenes, Flavonoids, Saponins, Sterols, Simple Phenolic Compounds, and Esters	Anti-rheumatic, Anti-gout, Antidiabetic, Anti-hyperlipidemic, Antimicrobial, Antioxidant, Antihypertensive, Antiseptic, Anti-eczema and Antidiarrheal	Shawky <i>et al.</i> , 2019
		Leaf, Flower and Root	n-hexane, Dichloromethane and Methanol	Phytol and Diterpenoid	Antiproliferative, Antioxidant, Cytotoxic	SaeidYaripouret <i>et al.</i> , 2017
		Leaf	Hexane, Methylene Chloride, Ethyl acetate and Butanol	Sterols and Fatty acids	Antioxidant	El-Shora <i>et al.</i> , 2016
		Leaf	Hydro-distillation	Essential oil	Antioxidant, Anti-diabetic, Antiobesity and Anti-bacterial	Kchaouet <i>et al.</i> , 2016
		leaves and Stem	Methanol, Ethyl alcohol, Acetone, Petroleum ether and Ethyl acetate		Antimicrobial, Cytotoxic and Larvicidal	Elbadry <i>et al.</i> , 2015

Table 2: Isolated endophytes from plants of the Zygophyllaceae family

S. No.	Plant Name	Plant part	Isolated endophytes		Reference
			Fungi	Bacteria	
1	<i>Zygophyllum album</i>	Root		<i>Pantoea sp.</i>	El-Megeed and Youseif, 2018
2	<i>Zygophyllum dumosum</i>	Root		<i>Kocuriarosea Micrococcus luteus Paenibacillustundrae Bacillus simplex Pseudomonas stutzeri P. brassica cearumBurkholderiaunamae</i>	Drora <i>et al.</i> , 2013
3	<i>Peganum harmala L.</i>	Leaf	<i>Exophiala Cladosporium Aureobasidium Trichoderma Verticillium Ailtemaria Rhizopus Aspergillus Penicillium Rhizooctonia Absidia Paraphaephaeria Trichophyton Bipolaris</i>		Yasmina <i>et al.</i> , 2018
4	<i>Tribulus terrestris L.</i>	Leaf	<i>Curvulariaaeria</i>		Sahani and Thakur, 2019
5	<i>Tribulus terrestris L.</i>	Leaf, stem and root	<i>Chaetomium sp Colletotrichum sp Pestalotiopsis sp. Phomopsis sp. Phyllosticta sp. Alternaria sp. Aspergillus sp. Curvularia sp. Fusarium sp. Nigrosporas</i>		Sahani and Hemalatha, 2018
6	<i>Tribulus terrestris L.</i>	Root nodule		<i>Cyanobacterium</i>	Mahmood And Athar, 1998

7	<i>Fagonia indica</i>	stem		<i>Enterobacter hormaechei</i> <i>Stenotrophomonas maltophilia</i> <i>Bacillus tequilensis</i> <i>Erwinia sp.</i> <i>Pantoea dispersa</i> <i>Pantoea cypripedii</i> <i>Enterobacter cloacae</i> <i>Bacillus subtilis</i>	Rahman et al., 2017
9	<i>Zygophyllum coccineum</i>	Leaf	<i>Cladosporium omanense</i>		Halo et al., 2019
10	<i>Zygophyllum mandavillei</i>	Leaf	<i>Cladosporium cladosporioides</i>		Yehia et al. 2020

Result and discussion

Endophytes are micro fauna which reside in the internal tissues of plants without any symptoms or adverse effects (Bacon and White, 2000). The beneficial relationships of endophytes with plants exhibit in various aspects such as enhance growth of plants (Waqas et al., 2012, Dingle and McGee, 2003), production of various bioactive compounds (Firáková et al., 2007; Rodriguez et al., 2009), to enhance the production and accumulation of plant secondary metabolites that serve as a potential source of drug along with various applications in food, agriculture, cosmetics and pharmaceutical industries (Strobel and Daisy, 2003; Shwab and Keller, 2008; Jalgaonwala et al., 2011; Godstime et al., 2014; Shukla et al., 2014).

In this family many plants have been studied for the occurrence of endophytes as shown in table 1. These plants also have to be associated with many biological, ethnopharmacological and therapeutic properties and they are also used as a potential source of medicines (Kour et al., 2016). Presence of endophytes in these plants is an interesting facet of the interaction with their hosts and their capacity to improve the host's resistance against certain pathogens by providing several bioactive metabolites (Gunatilaka, 2006).

This review article has the main emphasis to review the recent research and development on Zygophyllaceae endophytes, new insights towards endophytes to produce secondary metabolites and an overview of their associated biological activities. The above study will also provide novel information that would prove to be useful for research, medicinal, agricultural potential, and application in plant pathology in the future. The association of endophytes within plants of Zygophyllaceae still needs to be evaluated, given due attention and developed so as to make them more practicable in the present health era.

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