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A critical appraisal on plant tissue culture studies in medicinally important plants

Karrola Bixapathi
M.SC.(Botnay)

The members of Sterculiaceae are valuable source of different kinds of useful products like wood, medicine, fiber, firewood and timber suitable for furniture, as well as decorative plants, pharmaceutical products and aestic items. In recent years the relevance of plant tissue culture methods has gained thrust to meet the growing demands for pharmaceutical industries since the genetic diversity of medicinal plants is decreasing hap hazardously. Conventional propagation and high demand of planting material are the major constraints for the large scale multiplication of medicinal species which can be met economically and efficiently in short span of time by in vitro propagation. Micropropagation is an alternative means of propagation that can be engaged in the conservation of flora in relatively shorter time. Tissue culture is useful for multiplying and conserving the useful species which are difficult to regenerate and thus can be saved from extinction. There is an only partial advancement explored at the research level to suggest tissue culture studies in Sterculiaceae. Conclusively, this appraisal is the first of its kind which emphasizes the procedures available for in vitro propagation along with some of the remarkable achievements carried in some pharmaceutically and commercially important plants by in vitro culture techniques of plants from this family.

Keywords: Pharmaceutical, medicinal, propagation, *in vitro*, Sterculiaceae

In many countries herbs and botanicals have a long history of medicinal use for alleviating human suffering from the very beginning of human civilization, and records of the use of these botanicals are available since about 5000 years ago (Gupta *et al*; 2010) . According to World Health organization (WHO) about 80% of world populations are still dependent on traditional medicines (Deshpande and Bhalsing; 2013). India holds an enormous area with wide variation in climate, soil, altitude and latitude. India with its biggest repository of medicinal plants in the world may perhaps maintain an important position in the production of raw materials either directly for crude drugs or as the bioactive compounds in the formulation of pharmaceuticals and cosmetics etc (Tiwari, 2008 and Deshpande and Bhalsing; 2014a). In India, nearly 15000 plant species are used as a source of herbal medicines coming from different families to cure problems ranging from anti-biotic to anti-infective and from anti-cancer to anti-aging (Tiwari; 2008). But in contrast however one such family which needs attention is family Sterculiaceae.

Family Sterculiaceae

Family Sterculiaceae is a family of flowering plants and often referred to as the chestnut family found throughout the world (Kirsty Reid; 2002) .The family name is based on the genus *Sterculia*. As traditionally circum-scribed the families Sterculiaceae, Malvaceae, Bombacaceae and Tiliaceae comprise the "core Malvales" of the Cronquist system and the close relationship among these families is generally recognized. It is quite a large family with 1,200 species (50 genera) which occurs in tropical and subtropical regions and mainly includes trees and shrubs (Kirsty Reid; 2002). However, some of the species are herbaceous. Sterculiaceae had previously been recognized as a family by most systematists. The most famous products of the family are chocolate and cocoa from *Theobroma cacao*, followed by kola nuts.

Medicinal significance of family Sterculiaceae

To a certain extent the members of the family Sterculiaceae serve as sources of medicine, fibre, firewood and timber suitable for furniture, as well as decorative plants (Van Wyk, 1974). Probably the most important member economically is the American cacao tree (*Theobroma cacao*), which is the source of commercial cocoa and chocolate (Kirsty Reid; 2002).Many species yield timber. The continued use of plants as food, as a source of beverages and for their medicinal properties depends on knowledge of the chemical constituents that are present (Harborne and Baxter; 1993).Many are rich sources of pharmaceutically important compounds like diosgenin (Shriram and Shitole; 2008 and Deshpande and Bhalsing; 2014b), β – sitosterol (Chawla and Bansal; 2014)The fruits are used as a stimulant, healing rituals and topical analgesic (Iwu; 1993)The seeds containing caffeine, is used as leprosy remedy, gastrointestinal disorders (Okwari *et al.,* 2000) The leaf decoction is drunk as an antimalarial, while the crushed leaves are applied over the affected area against leprosy. Leaves used as aperient, diuretic and insect repellent (Chopra *et al*, 1992). Roots used in conventional medicine for stomach complaints curing skin diseases and cleansing wounds and to treat venereal diseases (Hutchings; 1992; Wu; 1993; and Chhabra *et al*; 1993). Decoctions of bark used in delayed labour. The infusions of bark or wood are used for treating intestinal ulcers, stomach complaints, haemorroids and diarrhoea (Van Wyk *et al*., 1997). The gum obtained from various plants finds its use in medicine (Mujumdar *et al;* 2000).Some of the family members are purgative, emollient, abortifacient, anti-tussive, anti-rabies, anti-syphilitic (Kirsty Reid; 2002)

Many members of the family Sterculiaceae are propagated through tubers, stem cuttings or through seeds conventionally. But these methods have certain agronomic constraints like hampering the production by several significant viral, fungal diseases and availability lack of good healthy planting materials (Das *et al*; 2013). The conventional methods are slow and not adequate for rapid multiplication. Further, the yield is drastically reduced by viral and nematode infections etc. and also due to ruthless exploitation of medicinal herbs form natural habitats. Not only these but some of the members revive naturally through seeds, but however their cultivation rate and poor seed dormancy are crucial factors for its propagation. As a result of which many of the valuable useful plant members are getting extinct or endangered. Plant tissue culture technique would be useful for conservation of rare and endangered plants for the production of industrially important phytochemicals.

In vitro propagation may help to prevail constraints related with availability of high quality of planting material, tissue culture technique provides a way to increase the rapid production of medicinal and also enhances the production of useful bioactive biomedicinals (Bhalsing *et al*; 2000 and Deshpande and Bhalsing; 2014c). Though this family has such immense and valuable medicinal importance, but still there are no reports on tissue culture studies in family Sterculiaceae. There is an only limited progress at the research level to suggest tissue culture of Sterculiaceae. Hence, the present appraisal summarizes firstly some of the important reports on the *in vitro* propagation of medicinally important members form family Sterculiaceae from literature data of recent years. This review will focus the significant achievements of recent years in the field of micropropagation of Sterculiaceae.

Medicinally important plants from Sterculiaceae

Sterculia urens (Roxb)

Sterculia urens is a moderate sized, deciduous tree belonging to the family Sterculiaceae (Town et al; 2008). It is commonly known as `gum karaya tree'. This gum is a complex polysaccharide. It is used as an ingredient in

the preparation of emulsions, lotions, denture fixative powders, bulk laxatives, as a pulp binder in the preparation of thin papers. The gum also has applications in petroleum, textile, pharma, food and dairy industries. It has a wide application in food, baking and dairy industries (Gautami and Bhat; 1992). The gum is in great demand both within and outside India. Considerable part of the gum produced in India is exported (Subhashini et al; 2010)

Guazuma crinita Mart

It's a tropical tree species of medium height with a light hardwood. This species is used has good working properties that has been mainly used for light construction, interior joinery, panelling, mouldings, cases, packing, and matches (Emilio et al; 1997).

Hildegardia populifolia (Roxb) Schott and Endl *Hildegardia populifolia,* an endangered indigenous medium sized tree species of family, Sterculiaceae. The leaf extract is known to possess wound healing properties (Anuradha and Pullaiah; 2001). The whole plant extract is used to cure malaria and dog bite Varaprasad et al; (2009). The leaf and stem bark extracts are reported to have antimicrobial (Saradha and Paulsamy; 2012a), antioxidant (Saradha and Paulsamy; 2012b) and anti-inflammatory activities (Saradha and Paulsamy; 2013). The fiber extracted from the bark is used for domestic purposes

Sterculia foetida L

Sterculia foetida is a tropical plant used as a timber for doors of huts, dugout canoes, boat planking, guitars and carved toys. The gum is used for bookbinding, fire wood and charcoal (Yoganandam et al; 2012). The seeds are eaten as purge/dewormer. The oil from seeds has its use in local culinary and traditional medicine. The leaves and bark is of medicinal importance. The leaves exhibit anti inflammatory activity in acute carrageenan induced rat paw edema. (Mujumdar et al; 2000).Oil from the seed is extracted on local scale to be used in medicine. (Rastogi and Mehrotra; 1993)

Sterculia setigera Del

S. setigera is a multifunctional plant species used for the treatment of boils, inflammations, chicken–pox, measles, dysentery, syphilis, epilepsy, jaundices, malaria and leprosy traditionally (Igoli et al; 2005). The boiled leaves are used to treat malaria, and the stem bark decoction is used for the treatment of asthma, bronchitis,

wound, fever, toothache, gingivitis sore, abscess, and diarrhea (Lawal et al; 2010). The anti -bacterial and anti-fungal activities of dried bark, dried fruit and the root of *S.setigera* against common microbes species like *Bacillus subtilis*, *Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Aspergillus niger* and *Candida albicans* have been reported (Ibrahim et al; 2012)

Helicteres isora L

It is commonly known as East Indian screw tree or red isora or spiral bush which appears as an arborescent sub deciduous shrub or small tree. This plant finds its use in traditional medicine since every part of this plant is used in Ayurvedic system of medicine. The root juice and bark of *Helicteres isora* is claimed to be useful in snake bite, diabetes, asthma, blood disorder, cough, colic, diarrhoea, dysentery, stomach affections, intestinal infections, emphysema, and also as a urinary astringent (Shriram et al. 2008).The fruits are astringent, acrid, refrigerant, demulcent, constipating, and stomachic possessing anti HIV activity (Otake et al. 1995). The decoction of the root is mixed with turmeric powder and applied externally to treat cuts and wounds by the ethnic people of Rayalseema region of Andhra Pradesh, India (Nagaraju and Rao; 1990). The roots possess hypolipidemic and antihyperglycemic activities (Kumar and Murugesan; 2008). The plant is an recently investigated important source of Diosgenin, a steroidal sapogenin which forms a precursor

for the chemical synthesis of steroidal drugs, oral contraceptives and is tremendously important to the pharmaceutical industry(Deshpande and Bhalsing; 2014b)

Tissue culture studies in medicinally important family members of Sterculiaceae

Tissue culture studies in family Sterculiaceae has been achieved by using different explants for rapid regeneration and multiplication. Several factors are reported to influence the growth of *in vitro* propagated plants. Various workers used different explants for propagating their plant by culturing different medicinally important plants from Sterculiaceae (Table 1).

Micro-propagation of *S. urens* via cotyledonary node segments was reported by Purohit and Dave; (1996) on MS medium containing 2.0 mg/L BAP. While, Emilio *et al*; (1997) reported tissue culture of an endemic tropical tree species *Guazuma crinita* Mart by shoot organogenesis from root and petiole explants on Woody plant medium (WPM) supplemented with Zeatin (trans-6-(4-hydroxy-3-methylbut-2- enyl) amino-purine). Sunnichan *et al*; (1998) worked with *Sterculia urens* (Roxb) and propagated the plant using nodal explants in the adult growth phase on MS basal medium fortified with 6.62 µM BAP. A tissue culture study of an endangered tropical forest tree *Hildegardia populifolia*
(Roxb) Schott and Endl was carried by Anuradha and Pullaiah; (2001) by culturing nodal explants on MS medium with 2.0 mg/L BAP along with a significant remarkable achievement of somatic embryo formation from immature zygotic embryo explants when fortified with 3.0 mg/L α – Naphthalene Acetic Acid (NAA) and 1000mg/ L Casein Hydrolystae (CH). In another report, Anita and Pullaiah; (2002) micropropagated *Sterculia foetida* through hypocotyls and shoot tip explants on MS medium fortified with 2.0 mg/ L BAP. Town *et al*; (2007) developed a protocol for large scale propagation of *Sterculia urens* via cotyledonary nodal cultures and reported that Thidiazuron (TDZ) at a concentration of 2.27 µM was most effective in inducing bud break while cytokinin alone was responsible for enhanced frequency of shoot regeneration. While, in another research, Town *et al*; (2008) designed a reproducible procedure for *Sterculia urens* by using intact seedlings as source of explants on MS medium supplemented with 5.0 µM TDZ + 1.5 µM GA3 + 0.1% ascorbic acid. Shriram *et al*; (2007) reported direct organogenesis of sub deciduous shrub of *Helicteres isora* through nodal explants on MS medium containing 13.94 µM Kinetin + 13.31 µM BAP. In another research work by Shriram *et al*; (2008), MS media fortified with 13.32 µM BAP + 2.32 µM Kinetin was found effective for indirect organogenesis in *Helicteres isora* via shoot tip explants. Subhashini devi *et al;* (2010) reported micropropagation of *Sterculia urens* though nodal cultures and found that MS medium fortified with TDZ at a concentration of 0.90µM and BAP at a concentration of 13.33µM gave best results. Peroxidases, poly phenol oxidase, total proteins, total carbohydrates and total phenols were biochemically analyzed at an interval of 20, 40 and 60 days and biochemically analyzed from *in vitro* derived plants. An *in vitro* procedure for micrografting of adult scions of *Sterculia setigera* was developed Dame *et al*; (2010) to overcome low rooting in adult shoot by grafting axenic micro shoots from adult trees as scions on rootstock seedlings by culturing them on MS medium supplemented with 1.5 mg/L BAP.

Table 1. Plant tissue culture studies in family Sterculiaceae

Medicinal plant Species	Percentage of regeneration	Explant source	References
Sterculia urens (Roxb)	30%, 30% and 60%	Nodal segment, cotyledonary node, intact seedlings	Purohit and Dave; 1996 Sunnichan *et al;* 1998; Town *et al*; 2007 and 2008; Subhashini devi *et al*; 2010
Guazuma crinita Mart	90%	Root and petiole	Emilio *et al*; 1997;
Hildegardia populifolia (Roxb) Schott and Endl	30%	Nodal and immature zygotic embryo	Anuradha and Pullaiah; 2001
Sterculia foetida L	40%	Hypocotyls and shoot tip explants	Anita and Pullaiah; 2002
Sterculia setigera Del	100%	Micrografting of adult scions	Dame *et al*; 2010
Helicteres isora L	79% and 73%	Nodal and Shoot tip explants	Shriram *et al;* 2007 & 2008
	75%	Axillary bud	Chawla and Bansal; 2014

Conclusion

In vitro propagation can become an important alternative to conventional propagation for wide range of plant species like threatened, medicinal, ornamental, endangered, endemic etc. These techniques would greatly contribute to develop economically important plant species of the future on a large scale. Thus, the present appraisal reviewed the compressive compilation of tissue culture studies in different medicinal plants belonging to the family Sterculiaceae via different explants. Thus, we can conclude that the regeneration system is repeatable and can be easily used to regenerate plants of economic importance from the information based on the data of the present study.

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