COMMIPHORA WIGHTII (GUGGUL) AN ENDANGERED AYURVEDIC DIVYAUSHIDHI

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The World Health Organization (WHO) estimated that 80% of the population of developing countries relies on traditional medicines, mostly plant drugs, for their primary health care needs (Bannerman, *et.al.,* 1983). Also, modern pharmacopoeia still contains at least 25% drugs derived from plants and many others which are synthetic analogues built on prototype compounds isolated from plants. Demand for medicinal plant is increasing in both developing and developed countries due to growing recognition of natural products, being non-narcotic, having no side-effects, easily available at affordable prices and sometime the only source of health care available to the poor. Medicinal plant sector has traditionally occupied an important position in the socio cultural, spiritual and medicinal arena of rural and tribal lives of India.

In recent years, the growing demand for herbal product has led to a quantum jump in volume of plant materials traded within and across the countries. Though India has a rich biodiversity, the growing demand is putting a heavy strain on the existing resources. While the demand for medicinal plants is growing, some of them are increasingly being threatened in their natural habitat.

About 90% of medicinal plants used by the industries are collected from the wild. While more than 800 species are used in production by industry, less than 20 species of plants are under commercial cultivation. Many plants are completely destroyed by the collectors because of the use of parts like roots, bark, wood, stem and the whole plant in case of herbs. This will pose a definite threat to the genetic stocks and to the diversity of medicinal plants if not used sustainably in the very near future.

Commiphora wightii popular by its vernacular name GUGGUL is one of most important medicinal plant of our traditional system of medicine and also having a nice status in modern research and drug system. It is the source of valuable oleo-gum-resin known as GUGGUL gum. GUGGUL gum have many medicinal and non medicinal properties. As a result the plant has been exploited and its natural population is dwindling thus making it an endangered species. GUGGUL has found its name in the IUCN red data book.

TAXONOMIC POSITION

Kingdom : Plantae
Division : Angiosperm
Class : Dicotyledon
Subclass : Polypetalae
Series : Disciflorae
Order : Geraniales
Family : Burseraceae
Genus : Commiphora
Species : wightii

Vernacular names

Eng.- Hill Mango, Gum gugul, Indian bdellium. **HINDI-** Guggu. Gogil, Guggul, Gugal, Mukul, Ranghan, Turb. **Beng.-**Guggul, Gugal, Mukul, Ranghan, Turb. **Guj.-** Guggul, Gugal, Mukul, Ranghan, Turb. **Kan.-** Kondamamidi, Guggule, GUGGULa. **Mal.-** Itinnil. **Mar. –** Guggul, GUGGULa. **Tam.-** kihuvai,Maishakshi, Gukkal, Guggulu. **Tel.-** kondamamidi, Guggul, Miasakshi. **Arab.**-Moql. Moqle-arzagi, Moqle-arsaqi aflatan, Muqlul yahud. **Sind. –** Gagaru. **Unani**- Afaletana, Mikal.

DISTRIBUTION OF GENUS *COMMIPHORA*

International

The genus *Commiphora is* widely distributed in tropical region of Africa, Madagascar and Asia. The distribution further extends to Australia and the Indian Ocean and Pacific islands. Occurrence of *Commiphora* spp. in South-west Africa has been confirmed (Van der Watt 1974, 1975) and Lisowski *et al (*1972) recorded different species *of Commiphora* from Zaire. Petiole anatomy (Van der Watt *et al* 1973) and branching pattern (Thomasson, 1972) have formed a basis for the identification of various species *of Commiphora* in Africa. *Commiphora* spp. is reported to occur in Arabia, Tropical and Southern Africa and India (Rajputana) - (Khan A.H., 1958). *Commiphora wightii* (Am.) Bhand. is also reported to occur in Pakistan indigenouslv in Hyderabad (Sindli) Kalat division (Khan. A.H., 1958) and Baluchistan and Sindh (Atal *C.K.,etal,* 1975).

National

In Indian sub-continent *Commiphora* species occur in India, Pakistan, Baluchistan etc. In India six species *of Commiphora* including *C. wightii* (Arn.) Bhand. are distributed in South-Westem India and parts of Central India which is represented by Kerala, Kamataka, Tamilnadu, Andhra Pradesh, Maharashtra, Madhya Pradesh, Gujarat and Rajasthan states, besides stray occurence in other states. The Guggulu yielding species *Commiphora wightii* (Am.) Bhand. is widely distributed in Gujarat and Rajasthan, it is however also found occasionally in some parts of Maharashtra, Madhya Pradesh and Kamataka .

Regional

Rajasthan: In Rajasthan it occurs in the districts of Jaisalmer, Jodhpur. Barmer,, Sirohi. Pali, Nagaur, Sikar, Churu, Bikaner and Jhunjhunu. Plants in low density are also found in Jalore, Siwana, Jaswantpura (Jalore district), Bhinmal, Jassi, Bisala, Chohatan etc. and in Udaipur, Alwar, Ajmer, Sawai Madhopur, Bundi, Kotaand Jaipur areas of Rajasthan.

Gujarat: In the state of Gujarat guggulu is found in whole of Kutch Division, besides Kara hills of Khawada region, in North of Bhuj, Nakhatrana, Zava, Dayapur, Rawapur, Lakhpat. Garoli, Besulpur, Mum, Amara, Ganjansar and ravines of Mahi river (Atal, **C.K.** *et al,* 1975).

ACTIVE PRINCIPALS IN GUGGUL

The National Chemical Laboratory (NCL), Pune, in collaboration with the Central Drug Research Institute (CDRI), began a detailed chemical study of GUGGUL and found out that GUGGUL has a complex structure made up of various compounds such as lignans, lipids, diterpenes and steroids. Ten steroids have been isolated from the resin, among these Z-GUGGULsterone and E-

GUGGULsterone are known to be bioactive. These two compounds are now known to possess a high degree of human bioactivity and have been shown in studies to affect many biological processes including thyroid metabolism, cholesterol management, and dermal functions. In each of these areas, guggulsterones were shown in studies to be highly effective modulators with near drug-like potency. The other components exert a synergistic activity.

Quercetin, its 3-O-α-L-arabinoside, 3-O-β-D-galactoside-, 3-O-α-L-rhamnoside-, and 3-O-β-D-glucoronide, elagic acid and pelargonidin 3, 5-di-O-glucoside (flowers); linoleic, oleic, palmitic and stearic acids, campesterol, cholesterol, β-sitosterol, stigmasterol and α- spinasterol (seed oil); myrcene, dimyrcene (comphorene), polymyrcene and caryophyllene (essential oil); lignans, sesamin, pluviatilol, guggulligunans I and II, myricyl alcohol, β-sitosterol, series of long chain polyol esters derived from homologous tetrols (guggultetrols) and ferulic acid (D-xylo-guggultetrol- 16 to 22 ferulate), monocyclic diterpenoids, viz., α- camphorene, cembrene, cembrene A, 2- hydroxyl- 4, 8, 12 trimethyl-1- isopropyl- 3,7,11- cyclodecatriene (mukulol; allyclembrol), cholesterol, three C-27 guggulsterols I, II and III and several pregnane derivaties, Z-guggulsterol, guggulsterol VI, two hypolipaemic agents, viz., Z- and E- giggi;sterpmes (4, 17 (20)- pregnadien- 3, 16- diones), 20 α-amd 20 β- hydroxyl-4- pregnen- 3- one, 16 β- hydroxyl-4, 17 (20) Z- pregnadien- 3- one and 16 α-hydroxyl- 4- pregnen- 3- one, some aliphatic tetrols- octadecan-1, 2, 3, 4-tetrol, eicosan, 1, 2, 3, 4-tetrol and non-adecan- 1, 2, 3, 4-tetrol (gum resin); Z- guggulsterone (oleresin); allylcembrol, amino acids, viz., alanine, arginine, aspartic acid, cystine, glutamic acid, histidine, isoleucine, leucine, lysine, praline, serine, threonine, tryptophan, tyrosine and valine (plant) (Anonymous, 2001)

The GUGGUL gum-resin has been used for centuries as part of India's traditional medicine called Ayurveda. In today's modern world of advanced pharmacy, this resinous sap is processed and purified, and then standardized for a given amount of its active plant sterol guggulsterone [4,17(20)-pregnadiene-3,16-dione]. Guggulsterones and guggulsterols naturally occur in *C. wightii*. Concentrations of gum guggul vary from plant to plant growing in various locations. The total percentage of guggulsterones ranged from 0.75 to 2.35%. In every case, the concentration of the Z isomer was more than twice that of the E isomer (Sharma, 1994).

The crude gum GUGGUL was found to contain 2% GUGGULsterones. Its ethyl acetate extract contain 4% to 4.5% GUGGULsterones. The neutral subfraction contain 4.2% to 4.7% GUGGULsterones. The ketonic subfraction of neutral subfraction contain 35% to 40% GUGGULsterones, from which the 10% E- and Z- GUGGULsterones are derived (Mesrob et al., 1998).

AYURVEDIC PROPERTIES

1. **Rasa-** Tikta, Katu

2. **Guna-** Laghu, Ruksha, Tikashna, Vishada, Sara, Sukshma, Sugandhi (Old Guggulu),Snigdha, Pichchhila (Fresh Guggulu)

3. **Veerya**- Ushna

4. **Vipaka**- Katu

5. **Prabhava**- Tridoshahara, Rasayana

6. **Doshaghnata**- Vatakaphashamaka

7. **Rogaghnata**- Sandhivata, Amavata, Gandamala, Apachi, Granthi, Charmaroga, Arsha, Durgandha, Krimi, Vrana, Nadishoola, Gridrasi, Ardita, pakshaghata, Vatavyadhi, Vatarakta, Agnimandya, Vibandha, Yakridroga, Hridroga, Hridyavarodha, Pandu, Upadanshajanya-raktavikara, Shotha, Shleepada, Jeerna kasa, Shwasa, Kasa, Kshaya, Mootrashmari, Mootrakrichchhra, Pooyameha, Mootragatavikara, Shukradaurbalya, Klaibya, Kashtartava, yonivyapata, Prameha, Medoroga, Kushtha, Varnavikara, Sheetajanyavikara, Sheetajwara.

8. **Karma**- Shothahara, Vedanasthapana, Vranashodhana, Vranaropana, Jantughna, Varnya, Kushthaghna, Nadibalya, Deepana, Anulomana, Pittasaraka, Yakridottejaka, Arshoghna, Krimighna, Koshthagatadurgandhinashaka, Hridya, Raktavardhaka, Raktaprasadana, Gandamalanashaka, Kaphadurgandhahara, Ashmaribhedana, Mootrala, Sheetaprashamana.

9. **Fresh Guggulu-** Uttejaka, Rasayana, Balya, Kamottejaka, Artavajanana, Vrishya, Vandhyatvadoshanivaraka.

10. **Old Guggulu-** Shukranashana, Lekhana, Medohara.

11. **Toxic effect-** Inappropriate dose (Mithya yoga) can cause damage to liver and lungs and over doses can cause vertigo, dryness in mouth, impotence, debility, musclewasting and thus contra indicated in these diseases (Anonymous, 2001)

FACTORS AFFECTING GUGGUL PLANT SURVIVAL

GUGGUL is now on the verge of extinction. It is placed under the category of rare and endangered plants in the IUCN Red Data Book. Main reasons for the deteriorating conditions of GUGGUL are summarized below:

1. *Seed formation and Poor germination:* seeds are the result of apomixes so their formation is very irregular. Seed maturation in case of GUGGUL depends upon the development of cellular endosperm. The endocarp of the fruit is very hard and does not allow entry of water, exchange of gases and expansion of embryo. So the seeds if not taken out from the endocarp or if the endocarp is not made porous, the germination of seed may not take place at all. So under natural conditions germination percentage is very low. Experimental study at GUGGUL herbal farm, Mangaliawas during 1981, 1988, 1989, 1990 indicated 1.4% germination, out of 1480 seeds sown, (Table 2),Yadav *et al*., 1999.

2. *Changing climatic conditions & prevailing drought:* Due to global warming, temperature is increasing and rainfall is decreasing. The natural habitat of Guggul is either dry / arid or highly salty where bacterial growth is normally slower as compare to other areas. This directly affects the microflora (Bacteria, Fungi, Algae) of soil, which damage the endocarp & increase the permeability of endocarp to water & shortens the dormancy period. Soil moisture is the first requirement of a seed to germinate naturally but due to drought conditions soil moisture has gone down below the critical level.

3. *Slow growth:* Although GUGGUL plant can be propagated either by seeds or by rooting of stem cuttings, in general the plant has very slow growth rate**.**

4. *Commercial maturation & death of plant:* This plant has commercial importance, because of its oleo-gum-resin. Plant takes nearly 8 to 15 years to become commercially exploitable for oleo-gum-resin. Tapping is the only process by which the gum-resin is taken out from the plant & after tapping many plants die. About 700-900 g resin come from each 4-6 foot-tall tree (Sabinsa Corp., 2000).

5. *Over exploitation:* Since GUGGUL gum has high medicinal values, pharmaceutical industries use it for their formulations. But the plant takes a long period to become commercially exploitable, the pharmaceutical industries purchase the gum from tribal people and pay them good money therefore tribal people exploit the naturally growing plants and sell the gum to pharmacies. This over exploitation has lead to loss of natural GUGGUL vegetation. GUGGUL plant seems dry and dead under natural conditions for a long period of the year therefore sometimes unaware village people use the dry GUGGUL wood for fuel.

6. *High medicinal values:* The GUGGUL gum that is derived from the plant *C. wightii* is an important ingredient of a large number of Ayurvedic formulations, hence it is considered as one of the **"Divyaushadhis"** in Ayurveda. Gugulipid has a long history of use in Ayurveda. The Atharva Veda, one of the four well-known holy scriptures (Vedas) of the Hindus, is the earliest reference to the medicinal and therapeutic properties of GUGGUL gum. Detailed descriptions regarding the actions, uses, and indications as well as the varieties of GUGGUL gum have been described in the Ayurvedic treatises, Charaka (1000 B.C.), Sushruta Samhita (600 B.C.), and Vagbhata (7th century A.D.). In addition, various Nighantus (medical lexicons) were written between the 12th and 14th centuries A.D. that were based on the Ayurvedic literature. Due to rich medicinal values plant is highly over exploited.

USES

Traditional Uses

The oleo-resin-gum is bitter, acrid astringent, aromatic, digestive, anthelmintic, anti-inflammatory, antiseptic, stimulant, liver tonic, diuretic, rejuvenating and general tonic and useful in vitiated conditions of vata, scrofula, sciatica, facial paralysis, leprosy, leucoderma, cough, asthma, bronchitis and hepatic disorders. The gum is well known for its anti rheumatic and anti-inflammatory actions. It is used for chronic ulcers and in the treatment of diseased bones. Resin is useful in nervous disorders and skin diseases. Resin also stimulates hair growth, acts as stimulant and expectorant in pulmonary diseases. Resin taken internally is said to reduce obesity. (Prajapati, N.D., *et. al.,* 2003).

In India the gum resin has also been used for treating various types of arthritis. Ayurvedic physicians extensively used GUGGUL gum for treating arthritis and related conditions for centuries. Bhils take the powder of bark orally with water to cure cough and cold. They also inhale the fumes of gum resin to cure fever, bronchitis, nasal congestion, laryngitis and phthisis. Grasias tribals dissolve the gum resin in warm water and use for gargling against pyorrhea, tonsillitis and pharyngitis. Tribals of Barmer give the gum orally to the children suffering from speech defects. Saharia tribals apply the paste of gum resin on cuts and injuries for early healing. The Kalbelia nomadic tribals take the fresh decoction of plant orally to cure asthma. The twigs are used as toothbrush.

Modern Uses

Modern therapeutic uses of guggul include treatment of nervous diseases, hemiplegia, leprosy, marasmus, muscle spasms, neuralgia, ophthalmia, pyelitis, pyorrhea, scrofula, skin diseases, spongy gums, ulcerative pharyngitis, hypertension, ischaemia, hypertension, hemorrhoids, and urinary tract disorders (AyuHerbal.com, undated; Memorial Sloan-Kettering Cancer Center, 2003). More recently, C. mukul was found to be a relatively safe and effective supplement for osteoarthrtiis of the knee (Singh *et al*., 2003). Research studies showed that guggul is effective against aspects of cardiovascular disease. Guggul reduced the stickiness of platelets (Herbal Pharmacist, undated), and Gugulipid® was shown to be an efficacious and cost effective treatment of hyperlipoproteinemia (Ghatak and Asthana, 1995). The standardized fraction from Gugulipid from *C. wightii* (Guglip®) may be used to treat hyperlipidemia and atherosclerosis (Indian Institute of Science, undated). A webpage to sell Gugulon™ stated it is marketed to help lower cholesterol, to decrease high blood pressure, to "strengthen the structural system" and the immune system, to benefit the heart, to lower cholesterol and high blood pressure, and to eliminate toxins (XetaPharm Inc., 2000).

EFFECT OF GUGGUL

As Mentioned in Ancient Literature

Nervous system: Analgesic, nervine tonic, so guggul is useful in neuralgia, rheumatoid arthritis, sciatica, facial paralysis, hemiplegia and gout etc.

Digestive system: It is an appetizer by pungent and bitterness; laxative by snigdha, pichchila, sara and tikshna, liver stimulant, anti-haemorrhoidal and anthelmintic by bitter and ushna gunas. Hence guggul is useful in loss of appetite, constipation, liver diseases, and worms. In stomatitis guggul kept in the mouth helps in would healing.

Circulatory system: It is a cardiac tonic. It increase haemoglobin and leucocyte count and enhances blood quality. It helps in oedema, lymphadenitis, glandular enlargement and filarial when given for a longer period. It reduces blood cholesterol, increases white blood cells and stimulates phagocytosis (the process by which the white cells engulf and devour alien invaders in the body).

Respiratory system: Expectorant being snigdha and pichchila, useful in chronic cough and chronic asthma.

Urinary system: Lithotripter due to tikshna and diuretic properties and also useful in dysuria and gonorrhoea.

Reproductive system: Guggul is ushna, tikshna, increases sexual power and acts as an emmenagogue. It is also useful in oligosperima, impotency, dysmenorrohoea, leucorrhoea and other gynaecological disease. Due to snigdha and pichchila properties, it acts as an aphrodisiac.

Skin: Enhances complexion and useful in many skin diseases.

Temperature: Sheetaprashamaka by ushna property, its vapours are useful in typhoid.

Satmikarana: Guggul works on all tissues of body and is effective in rejuvenating body tissues and increasing strength. Fresh guggul is useful in weakness and loss of weight, but on becoming old, it is useful in diabetes and obesity. It is also a good rasayana in obesity and disease of vata-kapha. It also helps in digestion of oil and ghee. Guggulu is an excellent yogavahi (a compound with carries the other substances mixed with it deep in the tissues); when added to a compound, it potentiates its fellow ingredients. It is therefore usefully used in combination.

As Mentioned in Modern Literature

Cholesterol reduction **-** It is well established that orally administered guggulipid decreases LDL cholesterol and triglyceride (TG) levels while either having no effect on or slightly increasing HDL cholesterol levels. Depending on dosage, it generally reduces LDL and TG levels between 10 to 25 percent (Tolson, D.) Guggul functions in this respect by decreasing hepatic cholesterol biosynthesis. Two constituents of guggul, guggulsterones E and Z, have been identified as primarily responsible for its hypolipidemic properties, although these are definitely not the only active constituents in guggulipid. A study evaluated the mechanisms by which two compounds present in guggulipid, E- and Z-gugglusterone, decrease hepatic cholesterol levels. These findings suggest that guggulsterone lowers cholesterol levels by acting as an antagonist of the FXR bile acid receptor important in the metabolism of cholesterol (Urizar, N.L., 2002).

Anti-inflammatory **-** Guggulipid is a potent anti-inflammatory agent, as evidenced by many studies done on individuals with arthritis. The compound primarily responsible for the anti-inflammatory properties of guggul is myrrhanol A, which is found in the acidic fraction of the extract (Tolson, D.).

Reduction in acne **-** There are many anecdotal reports of guggul causing a reduction of acne. There has been only one clinical study done, in which guggul was shown to be as effective as tetracycline (an antibiotic commonly used to treat acne) (Tolson, D.).

Reduced oxidative stress **-** Guggulipid may significantly decrease lipid peroxidation. One controlled study showed a 33% decrease in lipid peroxides after 24 weeks of 50 mg of guggulipid per day (Tolson, D.).

External uses- Anti-inflammatory, analgesic, cleaning of wound and healing due to anti-bacterial action. Paste of guggul is locally applied in rheumatoid arthritis, cervical lymphadenitis, skin diseases, piles etc. It reduces foul smell and swelling of wound. Its vapours are useful as deodorant and disinfectant in the house. Gargling is useful in pyorhoea and dental disorders

Thus it is now a well known fact that the product GUGGULsterone is pharmochologically extremely significant and used in many preparations. The demand is too high and we are incapable to fulfill this demand therefore pharmacies imports oleo-gum-resin from Pakistan. According to Monthly Statistics of Foreign Trade of India (2002-2003), Published by Department of Commerce, Ministry of Commerce and industry, Government of India, total value of GUGGUL oleo-gum-resin imported from Pakistan during April2002-Mar2003 is of Rs. 12024421. We can save this much of Indian currency by saving GUGGUL plants and can also earn foreign currency by export.

Beside all these medicinal uses GUGGUL also have ecological importance. The species grows in very adverse desert conditions. Each species contains a specific set of genes which makes the species most suitable to grow and to survive in a specific agro climatic zone. GUGGUL is a typical desert tree species and highly adapted to this area therefore it must possess genes for survival under this harsh environment. These genetic resources may become useful for genetic manipulations in future, so GUGGUL must be saved.

PROPAGATION METHODS OF *COMMIPHORA WIGHTII*

Traditional Propagation methods

The plant grows wild in the arid, rocky tracts, also in coastal areas on sandy and sandy loam soils. The climate required is typically semi-arid, characterised by aridity of the atmosphere and extremity of temperature both in the summer and winter with average rainfall 356 mm from July to September. The pH of soil may vary from 4 to 8. Soil conservation practices and soil working and green manuring is recommended to improve its productivity. Guggulu can be propagated by seeds and also vegetatively.

(a) **Through seed-** Regeneration through seeds in Guggulu is very poor. The seeds sown in the months of June and July in well worked soil beds, germinate at the onset of monsoon rains. One month old seedling are transferred into plastic bags after 2 years, these seedling attain a height of 30-50cm and suitable for field planting. Better seed germination can be obtained by mechanical scarification (with sand paper) of seed coat and keeping these scarified seeds under running water for about 24 hours.

(b) **Vegetative propagation through stem cutting-** It is successful propagated through stem cuttings. Cuttings are obtained from healthy and diseases free branches and usually planted during late summer, when the plant is almost leafless. With the onset of monsoon, when foliation growth/flowering starts, the plant becomes physiologically active and cutting also show signs of sprouting in 25-50 days. Treatment of root hormones, viz., Credik-1 and Credik-2 in July and August, was found beneficial for development of roots. The plants after establishing in the nursery beds are transferred into plastic bags and then planted in the field during rainy season.

(c) **Air layering –** Firm and healthy branch, about 60-90 cm. long, is selected and 5 cm. ring on the wood is marked. The bark of the marked portion is removed from the stem. The exposed portion is covered by applying a ball of adhesive soil, holding it securely together with coir-fiber, bandaging firmly all round the branch. This bandaged portion is supplied with water drop by drop through the drip system. Temperature, moisture and oxygen directly influence the rate of cell division and enlargement, lack of light stimulate the production of root. Growing points are formed and develop rapidly on young wood. In 2 to 3 months when young adventitious roots are seen protruding through the layering, it may be severed form the parent plant and planted.

Transfer of rooted cutting- One year old plant, transferred to the pits in the field, are required to be irrigated at regular intervals for 3-4 years. The plants above 5 years are irrigated during summer and dry weather conditions. Nitrogen fertilizer is used for better growth. GUGGUL plants are damaged by termites and leaf spot and root-rot diseases. Neem leaves mixed in soil and about 5% elderine mixed with water is most effective to eliminate the termite. (Anonymous, 2001).

Drawback of Traditional propagation method

1. Rare and endangered plant species.
2. Poor seed set therefore most of the fruits are empty. Due to this percentage germination is always very low.
3. Plant is very slow growing and plant takes at least three years to give a proper thick cutting for vegetative propagation. When this cutting is harvested for propagation at that time new sprouts of last two years are completely destroyed because they are too thin and useless for vegetative propagation.

GUGGUL AND NEED OF TISSUE CULTURE

There is so much scarcity of GUGGUL plantations now, that we are importing the resin from neighboring countries like Pakistan. Above mentioned reasons makes it an endangered and problematic plant. This endangered plant should be conserved and tissue culture techniques give us a way for it. Tissue culture techniques are based on the concept of totipotency. Totipotency is the ability of single isolated plant cell to regenerate into a fully normal fertile plant. In plant tissue culture, we take a small part of plant (the explant), which under controlled and sterile conditions and after passages through various phases, is able to regenerate into an entire plantlet. Under tissue culture conditions, the plant loses the ability to photosynthesise, so it is imperative to provide all the micro- and macro- nutrients from outside in the form of various media. Moreover to achieve various growth patterns, different types of phytohormones are also provided in the medium on which the plant tissue is allowed to grow aseptically. The major advantage of the *in vitro* system, irrespective of their origin, i.e., whether plants arise from meristem or shoot tip cultures, via somatic embryogenesis or organogenesis are;

- Reproducible and rapid rate of multiplication of rare and endangered species.
- Pathogen free saplings.
- By-pass system for such species that are difficult to propagate by vegetative methods or by seeds.
- Production of plantlets all around the year uninterruptedly without any seasonal constraints.

Once the micro propagation protocols are established, it automatically becomes a potential tool not only for rapid afforestation, but also for making available, the active principle for the end user, which has to be an imperative outcome for medicinal plant research. Micro propagation has tremendous scope for further expansion and gainful utilization as-

1. The morphogenetically potential explants could be used for production of 'synthetic' seeds.
2. The increased variability observed in plants regenerated in tissue culture via callus phase, could be utilized in exploiting the somaclonal variations.
3. Can be used for germplasm conservation as well.

Looking at the magnitude of the problems associated with cultivation of GUGGUL, it is time that alternatives to conventional propagation techniques are sought. Not only can tissue culture aid in fast propagation of the plants but also once the regeneration protocol has been standardized, it can become a boon to the various pharmaceutical industries producing GUGGUL formulations.

Through tissue culture, the goal of large scale plant production can be achieved either by micro propagation or by somatic embryogenesis and organogenesis (shoot morphogenesis).

Moreover, cell suspension cultures can provide a way for the isolation of certain secondary metabolites that often act as active ingredient in various drug formulations.

Present work was started with the aim to develop an effective *in vitro* propagation protocol for mass multiplication of this endangered species. Tissue culture based system is the need of the hour for this species which is characterized by a poor seed germination percentage and an unstandardized macropropagation protocol.

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