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Medicinal Plants from Deccan Ecoregion, India: Traditional Knowledge, Ethnopharmacology, Cultivation, Utilization, Conservation and Biotechnology – Opportunities and Impediments

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ABSTRACT

An annotated synopsis of prominent Medicinal and Aromatic plants (MAPs) from the Deccan ecoregion of India viz., *Aegle marmelos*, *Andrographis paniculata*, *Argyreia nervosa*, *Aristolochia indica*, *Asparagus racemosus*, *Azadirachta indica*, *Bacopa monnieri*, *Bixa orellana*, *Boswellia serrata*, *Butea monosperma*, *B. superba*, *Centella asiatica*, *Celastrus paniculatus*, *Chlorophytum arundinaceum*, *C. tuberosum*, *Commiphora wightii*, *Costus speciosus*, *Curcuma pseudomontana*, *Cycas circinalis*, *Decalepis hamiltonii*, *Drosera burmanii*, *D. indica*, *Embelia ribes*, *Entada pursaetha*, *Fagonia cretica*, *Gardenia gummifera*, *Gloriosa superba*, *Gymnema sylvestre*, *Ocimum sanctum*, *Oroxylum indicum*, *Piper longum*, *P. nigrum*, *Plumbago rosea*, *Pterocarpus marsupium*, *P. santalinus*, *Pueraria tuberosa*, *Rauvolfia serpentina*, *R. tetraphylla*, *Santalum album*, *Saraca asoka*, *Schleichera oleosa*, *Sterculia urens*, *Strychnos nux-vomica*, *S. potatorum*, *Terminalia arjuna*, *T. chebula*, *T. pallida*, *Tinospora cordifolia*, *Urginea nagarjunae*, *Vanda tessellate*, *Vitex trifolia*, *V. negundo*, *Withania somnifera*, and *Zanthoxylum alatum*, ethnopharmacological utilization and conservation are presented in this paper together with the issues and challenges to achieve this goal. *Ex situ* conservation and cultivation of selected Redlisted plants of the Deccan ecoregion was initiated in 2000 at the University of Hyderabad and are being maintained in a field gene bank and seed bank. A special feature of the medicinal flora in the Deccan ecoregion is the preponderance of plants that provide raw material for addressing a wide range of medical disorders and pharmaceutical requirements.

Keywords: biodiversity, phytomedicine, plant resources

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INTRODUCTION

India has a rich diversity of plant resources spread over a wide spectrum of habitats. In 1999, the Ministry of Environment and Forests, Government of India evolved the National Biodiversity Strategy and Action Plan (NBSAP) which emphasized the strategies needed for conservation and sustainable use of biological diversity of 12 recognized ecoregions: 1. Deccan Plateau (Andhra Pradesh, part of Maharashtra, Karnataka, Tamil Nadu and Kerala), 2. Vindhya-Satpura Range, 3. West Himalaya, 4. Shivaliks, 5. Aravalli Range, 6. Gangetic Plains, 7. North-East India, 8. Central Forest Belt, 9. Eastern Ghats, 10. West Coast, 11. East Coast, 12. Western Ghats Boundaries for the Deccan Plateau: North = Narmada River, South = Cauvery River, East = Coromandel Coast (excluding Eastern Ghats); West = Western Ghats). Conservation of biological diversity aims to preserve, maintain, sustainably utilize, restore, protect, and enhance the variety of life in an area so that the abundance and distribution of species and communities provides for the continued existence and normal ecological functioning, including adaptation and extinction (Olorode 2004; Rao 2004).

The characteristic vegetation formations of the Deccan ecoregion are dry deciduous monsoon thorny forests with several endemic, endangered, rare and threatened plant species. Tribal and rural people in the Deccan ecoregion have rich information about plant wealth for human health (**Table 1**) (Hemadri 1994). This traditional knowledge is the basis for contemporary drug discovery strategies. Very few medicinal plants can be cultivated on a large scale and most of the raw material required is often collected from the wild. Therefore, there is an enormous pressure on these plant resources. In this context, sustainable utilization, cultivation and conservation are crucial to realize that yesterday's traditions are the drugs of tomorrow (Gurib-Fakim 2006).

There is immense potential of herbal plants in these areas and hardly 10-20% of the total contents available in the forest are being extracted. The local and scientific uses of these plants have been recorded from the participation of locals and experts. So far about 90 species of herbs and shrubs of medicinal uses have been identified. For ensuring the sustainability of the herbal yield it is very important to create awareness among local villagers the techniques for sustainable herbal plants. From 2000 to 2005, extensive fieldwork was carried out in the Deccan ecoregion and *ex-situ* conservation of Medicinal and Aromatic Plants (MAPs) has been launched including the establishment of a field gene bank and seed bank for Redlisted plants of the Deccan ecoregion (**Figs. 1-9**; Padmalatha *et al.* 2006c). Traditional knowledge and ethnopharmacy (the interdisciplinary science that investigates the perception and use of pharmaceuticals, especially traditional medicine within human society in relation to the cultural context), utilization and conservation of these MAPs follows.

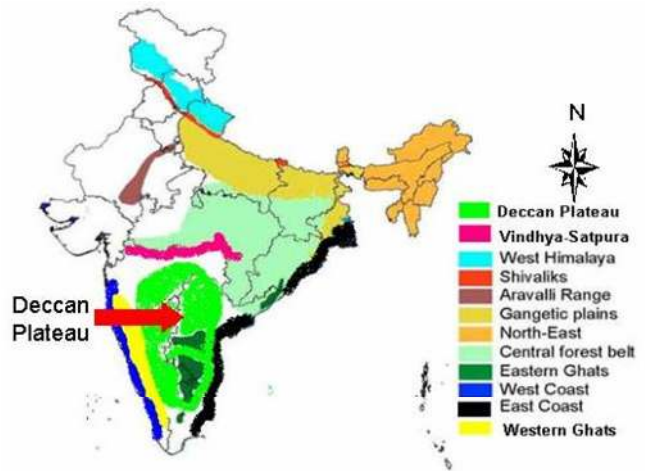

Fig. 1 Deccan Ecoregion of India. The National Biodiversity Strategy and Action Plan (NBSAP) of the Ministry of Environment and Forests, Government of India in 1999 recognized 12 ecoregions, and Deccan ecoregion is one of them. The boundaries for Deccan ecoregion are North= Narmada, South = Cauvery, East = Coromandel Coast (excluding Eastern Ghats), West = Western Ghats.

PROMINENT MAPs OF THE DECCAN ECOREGION

1. *Aegle marmelos* Corr. - Rutaceae

Trade name: Holy fruit tree (**Fig. 10**).

Threat status: Vulnerable (Ravikumar and Ved 2000).

Table 1 Plants of Deccan ecoregion used in traditional medicine (scientific name, Telugu name, family) (Hemadri 1994).

Scientific name	Telugu name	Family
Achyranthes aspera L.	Utthareni	Amaranthaceae
Actinopteris radiata (Sw.) Link	Mayurasikhi	Actinynopteridaceae
Alangium salviifolium (L.) Wang	Uduga	Alangiaceae
Alstonia scholaris (L.) R. Br.	Edakulapala	Apocynaceae
Andrographis paniculata (Burm. f.) Wall. ex. Nees	Nela vemu	Acanthaceae
Argyreia nervosa (Burm. f) Boj.	Samudrapala	Convolvulaceae
Aristolochia bracteolata Lam.	Gadidagadapaku	Aristolochiaceae
Aristolochia indica L.	Nalla eshwari	Aristolochiaceae
Asparagus racemosus Willd.	Satavari	Liliaceae
Balanites aegyptiaca (L.) Del	Garakayalu	Zygophyllaceae
Barringtonia acutangula (L.) Gaertn.	Kadapa chettu	Barringtoniaceae
Butea monosperma (Lam.) Taub.	Moduga theegalu	Fabaceae
Butea superba Roxb.	Theega moduga	Fabaceae
Calotropis procera (Ait) R. Br.	Gilledu	Asclepiadaceae
Cardiospermum halicacabum L.	Butta theega	Sapindaceae
Cassia fistula L.	Rela	Caesalpiniaceae
Cassia holosericea Fresen	Nelathangadi	Caesalpiniaceae
Centella asiatica (L.) Urb.	Saraswati aku	Apiaceae
Citrullus colocynthis (L.) Schard	Pedda papara	Cucurbitaceae
Clerodendrum serratum (L.) Moon	Bommala marri	Verbenaceae
Coccinia grandis (L.) Voigt	Thondaku	Cucurbitaceae
Costus speciosus (Koen.) Sm.	Kevu kanda	Zingiberaceae
Crataeva roxburghii Wt. et Arn	Ramajogi chettu	Capparidaceae
Crotalaria verrucosa L.	Thella eswari	Fabaceae
Curculigo orchioides Gaertn.	Nelathati gaddalu	Amaryllidaceae
Cycas circinalis L.	Arum	Cycadaceae
Decalepis hamiltonii Wt. et Arn	Maradi gaddalu	Asclepiadaceae
Dichrostachys cinerea (L.) Wt. et Arn.	Velthuru chettu	Mimosaceae
Dregea volubilis (L.) Benth. ex. Hook. f.	Thummidi theega	Asclepiadaceae
Elephantopus scaber L. Kukkurumuthu	Eddadugu	Asteraceae
Embelia sp. (R&S) A. DC	Konda pulleru	Myrsinaceae
Enicostema hyssopifolium (Willd). I.C. Verdoorn	Nela gorimidi	Gentianaceae
Erythroxylum monogynum Roxb.	Kanaragandham/Devadari	Erythroxylaceae
Gloriosa superba L.	Rayerudumpa theega/Pottidumpa	Liliaceae
Gymnema sylvestre (Retz) R. Br ex Schu.	Puttabhadra	Asclepiadaceae
Helicteres isora L.	Nulikaya	Sterculiaceae
Hemionitis arifolia (Burm.) Moore	Ramabhanum	Hemionitidaceae
Hesperethusa crenulata (L.) Del	Thorri elaka	Rutaceae
Leonotis nepetifolia (L.) Ait. f.	Sirinta	Lamiaceae
Lepidagathis hamiltoniana Wall.	Nakkapithiri gadda	Acanthaceae
Marsilea minuta L.	Arekuraku	Marsileaceae
Martynia annua L.	Mandrakppa kaya mokka	Martyniaceae
Mucuna pruriens (L.) DC	Duradagunta/Dulagondi	Fabaceae
Oroxylum indicum (L.) Vent	Rachapampini	Bignoniaceae
Pongamia pinnta (L.) Pierre	Kanuga	Fabaceae
*Pygmaeopremn*a herbacea (Roxb.) Moldnk	Gantu bharangi	Verbenaceae
Rauvolfia serpentina (Linn.) Benth ex. Kurz	Sarpagandha	Apocynaceae
Schleichera oleosa (Lour) Oken	Busi	Sapindaceae
Semecarpus anacardium L. f.	Jeedi	Anacardiaceae
Sida cordifolia L.	Bala	Malvaceae
Solanum surattense Burm. f.	Peddamulaka	Solanaceae
Soymida febrifuga (Roxb.) A. Juss	Somi/Rohini	Meliaceae
Stereopsermum suaveolens (Roxb.) DC	Kaligottu/Padiri	Bignoniaceae
Tephrosia purpurea (L.) Pers.	Vempali	Fabaceae
Terminalia tomentosa (Roxb. ex. DC) Wt. et Arn.	Nallamaddi	Combretaceae
Tinospora cordifolia (Willd) Miers ex. Hook f. et Th.	Thippathhega	Menispermaceae
Tylophora indica (Burm. f.) Merr	Mekameyani aku	Asclepiadaceae
*Urginea nagarjuna*e Hemadri & Swahari	Nagarjuna ulligadda	Liliaceae
Vanda tessellata Lodd. ex Loud.	Elkum	Orchidaceae
Vitex negundo L.	Vavili	Verbenaceae
Withania somnifera (L.) Dunal	Ashwagandha	Solanaceae
Zanthoxylum alatum Roxb.	Ranabelli	Rutaceae

Medicinal importance: Its leaves and fruits are mainly used in traditional and complimentary medicine for the treatment of a number health disorders. A decoction of plant leaves and fruit is used in remedies for dysentery, diarrhoea, upper respiratory tract infections and heart ailments. Freshly prepared aqueous and alcoholic extracts are reported to have a stimulatory effect on the heart and decrease the requirement of circulatory promoters (Veerappan *et al*. 2007). Pharmacological investigations confirmed suppression of fertility in male albino rats following the administration of 50% ethanolic extract (Chauhan *et al*. 2007). It acts as an antihyperglycemic and antidyslipidemic (Narender 2007). Holy fruit tree exhibits immunostimulatory function against *White spot syndrome virus* (WSSV) infection in black tiger shrimp (*Penaeus monodon*) (Citarasu *et al*. 2006; Balasubramanian *et al*. 2007). The seed extract has

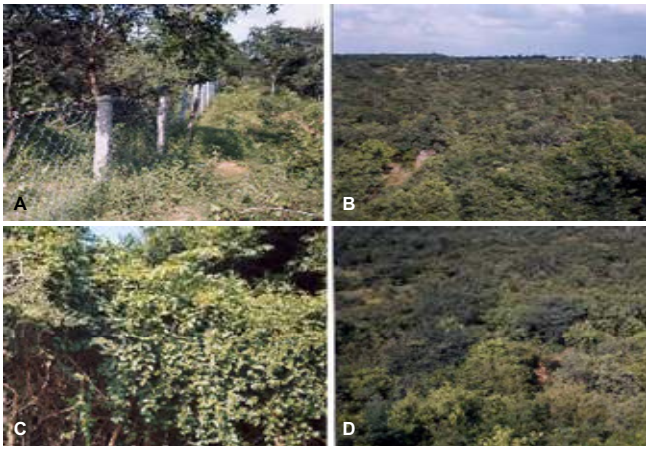

Fig. 2A-D: Field gene bank on the University of Hyderabad campus.

Fig. 3 Field experimental site for cultivation and conservation of MAPs. (**A**) *Commiphora caudata*; (**B**) *Oroxylum indicum*; (**C**) Greenhouse; (**D**) Concrete rings 2.5′ diameter filled with soil and farmyard manure were used to cultivate different accessions of MAPs.

Fig. 4 Maintenance of collected MAP germplasm in field experimental site. (**A**) Different accessions (seeds and propagules) collected were cultivated on 2.5′ diameter concrete rings amended with soil and farmyard manure. No synthetic chemicals and pesticides were used. (**B**) Perforated "polypots" for irrigation to conserve water; (**C**) *Centella asiatica* after 3 months of growth.

Fig. 5 Selected MAP germplasm in field experimental site. (**A**) *Curcuma longa*; (**B**) *Plumbago zeylanica*; (**C**) *Vitex trifolia*; (**D**) *Phyllanthus niruri*.

Fig. 6 Selected MAP germplasm in field experimental site. (**A**) *Centella asiatica* after 2 months growth; (**B**) *Centella asiatica* after 4 months growth; (**C**) *Carulluma*; (**D**) *Gymnema sylvestre*.

Fig. 7 Selected MAP germplasm in field experimental site. (**A**) *P. zeylanica*; (**B**) *Actinopteris*; (**C**) *Agave barbadense*; (**D**) *Plectranthus amboinicus*.

hypoglycaemic and antihyperglycemic activity in normal and diabetic rats (Kesari *et al*. 2007). Extracts of the plant interact with DNA and transcription factors (Lampronti *et al*. 2006), possesses antitumor and anticancer properties (Costa-Lotufo *et al*. 2005; Lampronti *et al*. 2006); alcoholic extract of its leaves protects against histamine-induced contractions in guinea pig ileum and tracheal chain (Arul *et al*. 2004) and serial extracts show anti-inflammatory, antipyretic and analgesic properties (Arul *et al*. 2005); fruit extracts in water showed hypoglycaemic effect in streptozotocin diabetic rats (Kamalakkannan and Prince 2003), *in vitro* antiproliferative activity on human tumor cell lines (Lampronti *et al*. 2003), alteration of thyroid hormone concentrations in male mice (Kar *et al*. 2002), and antidiarrhoeal activity in castor-oil–induced diarrhoea (Shoba and Thomas 2002). It contains bioactive alkaloids and compounds of pharmacological and microbiological importance

Fig. 8 Experimental site with germplasm accessions of MAPs. (**A**) Note the arch-shaped support in front of field lab entrance with *Celastrus paniculatus* seedling; (**B**) *C. paniculatus* after 2 yrs of growth; (**C**) *C. paniculatus* after 4 yrs of growth; (**D**) *Costus speciosus*; (**E**) *Tribulus terestris*; (**F, G**) *Drosera burmanii*; (**H-J**) *Frerea indica* (critically endangered) vegetative phase and well developed star shaped flower.

Fig. 9 Experimental site with germplasm accessions of MAPs. (**A**) *Wattakaka volubilis* (**B**) *C. paniculatus* (**C**); *Rauvolfia serpentina* and (**D-G**); Vegetative propagation of *C. paniculatus* using stem cuttings; (**H**) *Gloriosa superba.*

(Govindachari and Premila 1983; Pitre and Srivastava 1988); fruits and gum exudates are a rich source of medicinally important phytochemicals viz., neutral polysaccharides, glycoprotein, marmelene (an alkaloid), and other components of aegelinol, a minor lactonic constituent (Roy *et al*. 1971; Shoeb *et al*. 1973; Basu and Sen 1974; Roy *et al*. 1975; Chatterjee *et al*. 1978; Manandhar *et al*. 1978; Basak *et al*. 1981; Mandal and Mukherjee 1981; Sharma *et al*. 1981; Basak *et al*. 1982a, 1982b). Haravey (1968) and Arul *et al*. (1999) proved its effects on myocardium. Experimental data conducted suggest the extracts of the leaves of *A. marmelos* have a high margin of drug safety (Veerappan *et al*. 2007).

It is widely used in Indian Ayurvedic medicine for the treatment of diabetes mellitus (Kamalakkannan and Prince 2003) and asthma (Arul *et al*. 2004). The plant extracts exhibit antiproliferative (Lampronti *et al*. 2003, 2006), antioxidant (Vimal and Devaki 2004), analgesic (Shankaranth *et al*. 2007), antifungal (Rana *et al*. 1997), anticontraceptive (Arul *et al*. 2005), antidiarrhoeal (Shoba and Thomas 2001), antidiabetic and hypolipidemic activities apart from the (Kesari *et al*. 2006) regulation of hyperthyroidism (Kar *et al*. 2002).

Fig. 9 ***Aegle marmelos*** **– Holy fruit tree.** The fruits are widely used in Indian systems of medicine. The inset shows large fruits.

Phytochemicals: Furanocoumarin, isoproterenol, marmesinin (Vimal and Devaki 2004), 3-*O*-β-D-galactopyranosyl-D-arabinose, 5-*O*-β-D-galactopyranosyl-D-arabinose, and 3-*O*-β-D-galactopyranosyl-D-galactose, and the acidic oligosaccharides as 3-*O*-(β-D-galactopyranosyluronic acid)-D-galactose and 3-*O*-(β-D-galactopyranosyluronic acid)-3-*O*-β-D-galactopyranosyl-D-galactose (Roy *et al*. 1975), glucose, galactose, rhamnose, and arabinose (Mandal and Mukherjee 1981), hemicellulose, glucose, galactose, rhamnose, and arabinose (Basak *et al*. 1982), D-galactose, D-rhamnose, D-arabinose, and D-glucuronic (Mandal and Mukherjee 1980), galactose, arabinose, rhamnose, xylose, and glucose (Basak and Mukherjee 1982), arabinose, galactose, and glucose (Basak *et al*. 1981), galactose, glucose, arabinose and glycoproteins (Prabir *et al*. 1981), galactose, L-arabinose, L-rhamnose, D-galacturonic acid, 2,3,4-tri-*O*-methyl-L-rhamnose, 2,3,5-tri-*O*-methyl-L-arabinose, 2,3,4,6-tetra-*O*-methyl-D-galactose, 3,4-di-*O*-methyl-L-rhamnose, 2,5-di-*O*-methyl-L-arabinose, 2,4,6-tri-*O*-methyl-D-galactose, 2,3-di-*O*-methyl-L-arabinose, 2,4-di-*O*-methyl-D-galactose, 2-*O*-methyl-D-galactose, 2,3,4-tri-*O*-methyl-D-galacturonic acid, 2,4,6-tri-*O*-methyl-3-*O*-(2,3,4-tri-*O*-methyl-D-galactopyranosyluronic acid)-D-galactose, 2,4,6-tri-*O*-methyl-3-*O*-[2,4,6-tri-*O*-methyl-3-*O*-(2,3,4-tri-*O*-methyl-D-galactopyranosyluronicacid)-D-galactopyranosyl]-D-galactose, 3-*O*-β-D-galactopyranosyl-L-arabinose, 5-*O*-β-D-galactopyranosyl-L-arabinose, 3-*O*-β-D-galactopyranosyl-D-galactose, 6-*O*-β-D-galactopyranosyl-D-galactose (Roy *et al*. 1977), D-arabinose, D-galactose, D-rhamnose, and D-galacturonic acid, 2,3,4,6-tetra-*O*-methyl-galactose, 3,4-di-*O*-methyl-D-rhamnose, 2,5-di-*O*-methyl-D-arabinose, 2,4,6-tri-*O*-methyl-D-galactose, 2,3-di-*O*-methyl-D-arabinose, 2,4-di-*O*-methyl-D-galactose, 2-*O*-methyl-D-galactose, 2,3,4-tri-*O*-methyl-D-galacturonic acid, 2,4,6-tri-*O*-methyl-3-*O*-(2,3,4-tri-*O*-methyl-D-galactopyranosyluronic acid)-D-galactose,2,4,6-tri-*O*-methyl-3-*O*-[2,4,6-tri-*O*-methyl-3-*O*-(2,3,4-tri-*O*-methyl-D galactopyranosyl-uronic acid)-galactopyranosyl]-D-galactose (Roy *et al*. 1976), alkaloids and pyrrolizidine alkaloids (Arseculeratne *et al*. 1985), aegelinol (Chatterjee *et al*. 1978), coumarins (Shoeb *et al*. 1973; Basu and Sen 1974), marmeline, aegline, imperatorin, alloimperatorin and xanthotoxol (Sharma *et al*. 1981), *O*-(3,3-dimethylallyl)-halfordinol, *N*-2-ethoxy-2-(4-methoxyphenyl) ethylcinnamamide, *N*-2-methoxy-2-[4-(3′, 3′-dimethyl (Manandhar *et al*. 1978), *N*-2-[4-(3′,3′-dimethylallyloxy)phenyl]ethyl cinnamide, *N*-2-hydroxy-2-[4-(3′, 3′-dimethylallyloxy) phenyl]ethyl cinnamide, *N*-4-methoxystyryl cinnamide, *N*-2-hydroxy-2-(4-hydroxyphenyl)ethyl cinnamide and aegeline (Govindachari and Premila 1983).

Ethnopharmacy: The tribals eat the pulp of unripe fruits to treat dysentery. The roots and bark are used in the form of a decoction as a remedy for melancholia, hypochondriasis, intermittent fevers and palpitation of the heart. The leaf juice is used in treating diabetes apart from its usage as febrifuge. Fresh leaves are used as a remedy for dropsy, beri beri associated with weakness of the heart (Parrotta 2001).

Conservation measures: When the cotyledons from seedlings were cultured on MS medium with 2 mg L^{-1} benzylaminopurine (BAP) optimum bud induction was observed. The addition of indole-3-acetic acid (IAA) at 0.2 mg L^{-1} improved shoot regeneration efficiency. Adventitious shoots were elongated on MS medium containing 0.5 mg L^{-1} kinetin (KN) and 0.1 mg L^{-1} gibberellic acid (GA_3) Approximately 25% of regenerated shoots were induced to differentiate roots on half-strength Murashige and Skoog (MS) medium with 0.5 mg L^{-1} indole-3-butyric acid (IBA) (Hossain *et al.* 1994). Axilliary and terminal buds as explants were placed on MS medium supplemented with organic and inorganic salts. Various concentrations of auxins (0.05-5.0 mg L^{-1} IAA, IBA, α-naphthalene acetic acid (NAA) and 2,4-dichlorophenoxy acetic acid (2,4-D) and cytokinins (0.05−6.0 mg L^{-1} KN and BAP) were used. Each plant was specific in its requirement for auxin and cytokinin for production of multiple shoots. Regenerated shoots were subcultured for further multiplication on half-strength MS medium. Complete roots developed within four to six weeks on rooting medium. The regenerated plants were further acclimatized and transferred to the field (Arya and Shekhawat 1986).

2. *Andrographis paniculata* (Burm. f.) Wallich ex Nees - Acanthaceae

Trade name: Kalmegh.

Threat status: Indeterminate.

Medicinal and phytochemical importance: The leaf and root extracts exhibit anti diabetic (Reyes *et al*. 2006), anti inflammatory (Zhou *et al*. 2006), anti-malarial (Najila *et al*. 2002), anti tumour (Jada *et al*. 2007), antiplatelet (Thisoda *et al*. 2006), antimicrobial (Singha *et al*. 2003) and antioxidative (Tripathi *et al*. 2007) activities. Andrographolide 1, a diterpenoid lactone (Jada *et al*. 2007), acts as a cytotoxic agent (Rao *et al*. 2004). Another diterpenoid, dehydroandrographolide, was reported by Chen *et al*. (2007). Two flavonoids, identified as 5,7,20,30-tetramethoxyflavanone and 5-hydroxy-7,20,30-trimethoxyflavone, as well as several other flavonoids, andrographolide diterpenoids which suppresses the endothelial cell apoptosis apart from hepatotoxicity (Chen *et al*. 2004) were isolated from the leaf extracts. Polyphenols were obtained from the phytochemical investigation of the whole plant. Roots and aerial parts yielded a new flavone, 5-hydroxy-7, 20, 60-trimethoxyflavone and an unusual 23-carbon terpenoid, 14-deoxy-15-isopropylidene-11,12 didehydroandrographolide together with five known flavonoids and four known diterpenoids (Nanduri *et al*. 2004). The bioactive diterpene neoandrographolide was also isolated from the leaves (Rao *et al*. 2004). The plant extract was also used to check the semen quality (Mkrtchyan *et al*. 2005) (**Table 2**).

Ethnopharmacy: A decoction of the plant is considered as a blood purifier, used for treating jaundice and torpid liver and its extract or infusion is reportedly used to relieve fever. The powdered plant mixed with goat's milk is taken over a 40-day period as a treatment of tuberculosis among the tribals. The leaf juice is taken orally to treat jaundice, dyspepsia and general debility and a paste of the fresh plant is applied to the scalp to kill head lice. The dried powdered plant is taken with black pepper as a prophylactic against malaria or with water and sugar as a liver tonic. A decoction prepared from the leaves is used to relieve diarrhoea. The dried powdered root is given with water to children as an anthelminthic (Parrotta 2001).

Conservation measures: Callus obtained from leaf explants when cultured on MS medium with a reduced concentration of 2,4-D (2.26 μM) became embryogenic. This embryogenic callus gave rise to the highest number of embryos (mean of 312 embryos) after being transferred to half-strength MS basal liquid medium. The embryos were grown only up to the torpedo stage. A higher frequency of embryos developed from callus initiated on 2.26 or 4.52 μM 2,4-D underwent maturation compared to that initiated on higher concentrations of 2,4-D. The addition of 11.7 μM silver nitrate to half-strength MS liquid medium resulted in 71% of embryos undergoing maturation, while 83% of embryos developed into plantlets after being transferred to agar medium with 0.44 μM BAP and 1.44 μM GA_3. Most plantlets (88%) survived under field conditions and were morphologically identical to the parent plant (Martin 2004a).

3. *Argyreia nervosa* (Burm. f.) Boj. - Convolvulaceae

Trade name: Elephant creeper.

Threat status: Indeterminate.

Medicinal importance: See **Table 3**.

Ethnopharmacy: Source of murva to treat urinary, heart and other skin diseases. Roots are ground in rice water and used as an external application to the head to treat migraines. A preparation known as fortege with other ingredients (seed extracts of *Withania somnifera*, *Santalum album*, *Piper longum* and *P. nigra*) is used for treating common male sexual disorders (Bhalerao *et al*. 1980).

Phytochemicals: The occurrence of a sulfated flavonoid, i.e. Kaempferol 7-*O*-Me-3-sulfate was reported; its leaves contain flavone glycosides, kaempferol glycoside, kaempferol and quercetin (Mann *et al*. 1999).

4. *Aristolochia indica* L. - Aristolochiaceae

Trade names: Serpent root plant, Indian birth wort.

Threat status: Indeterminate.

Medicinal importance: Dried roots and leaves are used as an antidote for snakes, gastric stimulant, bitter tonic and Emmenagogue and mostly roots are used to treat dyspepsia, bowel troubles and intermittent fevers (Negi *et al.* 2003).

Phytochemicals: Aristolochic acid (Ganguly *et al*. 1986), phytosterols; sesquiterpene alcohols (Pakrasi *et al.* 1977), a phenanthrene derivative, aristololactam *N*-β-D-glucoside, and the steroids 3β-hydroxy-stigmast-5-en-7-one and 6β-hydroxy-stigmast-4-en-3-one were also isolated (Achari *et al*. 1981). N-glycoside and steroids (Achari *et al*. 1981) and ishwarone (Fuhrer *et al*. 1970) were reported from roots. From the roots two new sesquiterpene hydrocarbons, ishwarane and aristolochene, were isolated (Govindachari *et al*. 1970).

Ethnopharmacy: Antibacterial (Kumar *et al*. 2002; Shafi *et al*. 2006) and antifungal (Shafi *et al*. 2006) compounds were found. A decoction of the roots is considered as a stimulant and febrifuge in combination with black pepper and ginger, and used as a carminative for treating diarrhoea and other bowel complaints. The dried powdered roots are given with honey to treat leucorrhoea. The root powder mixed with mustard oil is used as an external application to ease body pain, the ground root is given as an antidote for snake bite. The matured leaves are used to treat asthma. The root pounded with black pepper is taken to treat rheumatism. The leaf juice is used to treat diarrhoea, cholera and inter-

Table 2 *Andrographis paniculata*: Medicinal uses, phytochemistry and ethnopharmacology.

Bioactive compounds and medicinal properties	Reference
In vitro cytogenetic effects on arsenic.	Avani and Rao 2007
Modulation of the expression of the pi class of glutathione *S*-transferase by andrographolides.	Chang *et al.* 2007
Determination of andrographolide and dehydroandrographolide by on-line coupling of dynamic microwave-assisted extraction with high-performance liquid chromatography.	Chen *et al.* 2007
In vitro anticancer activities of andrographolide analogues.	Jada *et al.* 2007
Amelioratory effect on liver, kidney, heart, lung and spleen during nicotine induced oxidative stress.	Neogy *et al.* 2007
Differential inhibition of rat and human hepatic cytochrome P450 by *Andrographis paniculata* extract and andrographolide.	Pekthong *et al.* 2007
Antiangiogenic activity.	Sheeja *et al.* 2007
Modulation of oxidative damage.	Tripathi *et al.* 2007
Modulation of immune response in mice immunised with an inactivated *Salmonella* vaccine.	Xu *et al.* 2007
HPLC and HPTLC densitometric determination of andrographolides and antioxidant potential.	Akowuah *et al.* 2006
Screening and optimization of total andrographolide content, yield and its components.	Bhan *et al.* 2006
Inhibitory effect of its extract and active diterpenoids on platelet aggregation.	Thisoda *et al.* 2006
Crude extract on mouse hepatic cytochrome P450 enzymes.	Jarukamjorn *et al.* 2006
Useful for the treatment of upper respiratory infection.	Kligler *et al.* 2006
Showed most promsing property to inhinit RANTES (=regulated on activation, normal T cell expression and secreted) secretion by influenza A virus (H1N1) infected human epithelial cells.	Ko *et al.* 2006
Anti-diabetic potential.	Reyes *et al.* 2006
Flow injection spectrophotometric determination of andrographolide.	Ruengsitagoon *et al.* 2006
Screening of plants acting against scorpion venom activity on fibroblast cell lysis.	Uawonggul *et al.* 2006
Simultaneous determination of andrographolide and dehydroandrographolide by microemulsion electrokinetic chromatography.	Zhao *et al.* 2006
Andrographolide-induced apoptosis in human cancer cells.	Zhou *et al.* 2006
A phase I clinical study of *Andrographis paniculata* fixed combination Kan Jang™ versus ginseng and valerian on the semen quality.	Mkrtchyan *et al.* 2005
Andrographolide suppresses endothelial cell apoptosis via activation of phosphatidyl inositol-3-kinase/Akt pathway.	Chen *et al.* 2004
Anti-malarial activity of some xanthones isolated from the roots.	Dua *et al.* 2004
Antihyperglycaemic activity.	Husen *et al.* 2004
Anticancer and immunostimulatory activity.	Kumar *et al.*
Flavonoids and andrographolides.	Rao *et al.* 2004
Synthesis and structure-activity relationships of andrographolide analogues as novel cytotoxic agents.	Nanduri *et al.* 2004
Double-blind, placebo-controlled, randomized, pilot clinical trial of Immuno-Guard® a standardized fixed combination of *Andrographis paniculata* Nees, with *Eleutherococcus senticosus* Maxim, *Schizandra chinensis* Bail. and *Glycyrrhiza glabra* L. extracts in patients with Familial Mediterranean Fever.	Amaryan *et al.* 2003
Separation of andrographolide and neoandrographolide from the leaves using high-speed counter-current chromatography.	Du *et al.* 2003
Antimicrobial activity.	Singha *et al.* 2003
A flavone and an unusual 23-carbon terpenoid.	Reddy *et al.* 2003
Protective activity of andrographolide and arabinogalactan proteins against ethanol-induced toxicity in mice.	Singha *et al.* 2003
A double blind, placebo-controlled study in the treatment of acute upper respiratory tract infections including sinusitis.	Gabrielian *et al.* 2002
Anti-malarial activity.	Rahman *et al.* 1999; Najila *et al.* 2002
Effect of Andrographolide and Kan Jang – fixed combination of extract SHA-10 and extract SHE-3 – on proliferation of human lymphocytes, production of cytokines and immune activation markers in the whole blood cells culture.	Panossian *et al.* 2002
Determination of bioactive diterpenoids by micellar electrokinetic chromatography.	Cheung *et al.* 2001
In vitro antifilarial effects.	Zaridah *et al.* 2001
Selective blocking in voltage-operated calcium channels in rat *vas deferens*.	Burgos *et al.* 2000
Hepatoprotective diterpenoids.	Jain *et al.* 2000
Cardiovascular activity of 14-deoxy-11,12-didehydroandrographolide in the anaesthetised rat and isolated right atria.	Zhang *et al.* 1987; Zhang *et al.* 1997
Ent-14β-hydroxy-8(17),12-labdadien-16,15-olide-3β,19-oxide: A diterpene from the aerial parts.	Jantan and Waterman 1994
Antihepatotoxic effects of major diterpenoids.	Kapil *et al.* 1993
Andrographolide protects rat hepatocytes against paracetamol-induced damage.	Visen *et al.* 1993
Reputated antidote for snakebite.	Martz 1992
Inhibition of HIV-1 infection *in vitro*.	Yao *et al.* 1992
Testicular toxicity assesment of dried extract in rats.	Burgos *et al.* 1977
The structure and stereochemistry of neoandrographolide, a diterpene glucoside.	Chan *et al.* 1971

Table 3 *Argyreia nervosa*: Plant parts and their medicinal importance.

Useful parts	Medicinal importance
Whole plant	Gleet, gonorrhoea, chronic ulcers, strangury.
Leaves	Emollient, vesicant, boils, wounds, ringworm and eczema and other skin diseases. Cures boils and other swellings, local stimulant, rubifacient.
Seeds	Tonic, hypotension and spasmolytic, aphrodisiac and diuretic, rheumatism.
Paste of the roots	Cough, cold and related fever.

mittent fevers. The seeds are used to treat inflammations and dry cough. The powdered stem bark is mixed in water with that of neem and *Cassia fistula* and is administered orally as an antidote to snake bite (Selvanayagam *et al.* 1994).

Conservation measures: The highest percentage of callus induction was 95% on MS medium supplemented with 2.0 mg L^{-1} KN and 1.0 mg L^{-1} BAP. The highest percentage (95%) of shoot regeneration was obtained on MS medium fortified with 2.5 mg L^{-1} KN and 1.0 mg L^{-1} BAP. The elongated shoots developed roots on medium containing 1 mg L^{-1} KN (Siddique *et al.* 2006). Best callusing was obtained on medium containing 1-5 mg L^{-1} BAP using stem explants. Bud and leaf initiation from the callus was also observed within 40 days of culture on MS medium with 2

mg L^{-1} BAP and 0.5-2 mg L^{-1} NAA (Remashree *et al*. 1997). The maximum number of shoots were induced on MS with 5 mg L^{-1} N^6-(2-isopentenyl) adenine (2-iP) alone (about 12-14 shoots) from shoot tips and nodal explants. Shoot differentiation occurred directly from the leaf bases as well as from the internodes when cultured on medium with 1-4 mg L^{-1} BAP and 0.8-2 mg L^{-1} NAA. Regeneration from the callus occurred when calli initiated on MS medium containing 0.6-4 mg L^{-1} NAA in combination with 0.8-3 mg L^{-1} BAP were transferred to medium containing 1-6 mg L^{-1} BAP alone. Rooting was observed on MS medium containing 1 mg L^{-1} IBA (Soniya and Sujitha 2006). MS medium, when supplemented with 0.54 µM NAA and 13.31 µM BAP induced the maximum number of shoots (45-50) from shoot tips and nodal segments. Basal medium supplemented with 2.69 µM NAA, 13.31 µM BAP and 1.0 mg L^{-1} PG induced the best results in terms of shoot bud regeneration from leaf derived callus. Direct *de novo* development of shoots from leaf segments was achieved when using 13.31 µM BAP along with 50 mg L^{-1} activated charcoal (AC). The microshoots were rooted on White's medium supplemented with 2.46 µM IBA (Manjula *et al.* 1997).

5. *Asparagus racemosus* Willd. - Liliaceae

Trade names: Wild carrot, water root, climbing asparagus, butter milk root.

Threat status: Indeterminate.

Medicinal importance: Tuberous roots are used for curing nervous disorders, tumours, dysentery, diarrhoea, inflamemations, leucorrhoea, leprosy, epilepsy, fatigue, cardiac debility, abortion, general debility, throat infections, tuberculosis, cough and bronchitis, stomachic, tonic, aphrodisiac, galactagogue, astringent, biliousness and rheumatism (Mandal *et al.* 2000); antioxidant against damage induced by γ-radiation in rat liver mitochondria (Kamat *et al*. 2000); antitussive effect of *Asparagus* against sulfur dioxide-induced cough in mice (Mandal *et al*. 2000); gastroduodenal ulcer protective activity (Sairam *et al*. 2003). Iinulinase is produced from luyveromyces marxianus YS-1 using the root extract of *A. racemosus* (Singh *et al*. 2006).

Phytochemicals: Molluscicidal (Chifundera *et al*. 1993), phytoecdysteroid (Dinan *et al*. 2001), immunoprotective (Diwanay *et al*. 2004), and immunoadjuvant (Gautam *et al*. 2004) shatavarins I and IV were isolated as the major components from the roots (Hayes *et al*. 2006a). Steroidal saponins (Mandal *et al*. 2006; Hayes *et al*. 2007), asparinins, asparosides, curillins, curillosides and shavatarin (Hayes *et al*. 2006b), isoflavone (Saxena and Chourasia 2001), 9,10-dihydrophenanthrene (racemosol) was isolated from the roots (Sekine *et al*. 1997). A new steroidal saponin, shatavarin V, (3-*O*-{[α-L-rhamnopyranosyl(1→2)][β-D-glucopyranosyl (1→4)]-β-D-glucopyranosyl}-(25*S*)-5β-spirostan-3β-ol), was isolated from the roots (Hayes *et al*. 2006a, 2006b). Five steroidal saponins, shatavarins VI–X, together with five known saponins, shatavarin I (or asparoside B), shatavarin IV (or asparinin B), shatavarin V, immunoside and schidigerasaponin D5 (or asparanin A), have been isolated from the roots (Hayes *et al*. 2007). Three steroidal saponins, racemosides A, B and C, were isolated from the methanolic extract of the fruits and characterized as (25*S*)-5β-spirostan-3β-ol-3-*O*-{β-D-glucopyranosyl(1 → 6)-[α-L-rhamnopyranosyl(1 → 6)-β-D-glucopyranosyl(1 → 4)]-β-D-glucopyranoside}, (25*S*)-5β-spirostan-3β-ol-3-*O*-α-L-rhamnopyranosyl(1 → 6)-β-D-glucopyranosyl(1 → 6)-β-glucopyranoside and (25*S*)-5β-spirostan-3β-ol-3-*O*-{α-L-rhamnopyranosyl-(1 → 6)-[α-L-rhamnopyranosyl(1 → 4)]-β-D-glucopyranoside}, respectively (Mandal *et al*. 2006).

Ethnopharmacy: The roots are used in the treatment of kidney and liver disorders, gleet and gonorrhoea, and fever. The dried powdered roots are used to increase lactation in nursing mothers and to treat leucorrhoea, sexual weakness and rheumatism. The fresh root juice mixed with honey is given to relief dyspepsia and memorrhagia. An aqueous extract of the crushed roots along with other medicinal plants is used in the treatment of leucorrhoea. The paste prepared from the roots along with the leaves of *Zizyphus* is applied to the forehead at bed time as a treatment for insanity. The paste prepared from roots mixed with black pepper is applied externally to treat hydrocele. The leaf paste is used in combination with warm water baths to relief scabies (Pieroni *et al.* 2007).

Conservation measures: Nodal segments produced multiple shoots while apical meristems and cladodes proliferated into callus. Among the media tested, MS media supplemented with 0.l mg L^{-1} NAA + 2 mg L^{-1} KN favoured multiple shoot induction in 80% of cultures while high levels of NAA promoted callus induction (Vijay and Kumar 2004). It is a plant requiring conservation (Bopana and Saxena 2007).

6. *Azadirachta indica* A. Juss - Meliaceae

Trade name: Neem tree.

Threat status: Common.

Medicinal and phytochemical importance: Nimbidin, a major crude bitter principle extracted from the oil of seed kernels is used in several biological activities. It possesses significant properties; anti-inflammatory (Bhargava *et al.* 1970), arthritis (Pillai 1981), antipyretic (David 1969), antiulcer as well as histamine or cystamine-induced duodenal ulcers (Pillai and Santhakumari 1984) antihistamine (Pillai and Santhakumari 1985) spermicidal (Sharma and Saksena 1959) antifungal and bactericidal (Murthy and Sirsi 1958; Khalid *et al.* 1989), diuretic (Bhide *et al.* 1958), antifertility, hypoglycaemic, immunostimulant, analgesic, antimalarial and antifeedant activities (Govindachari 1992; Biswas *et al.* 2002) (**Table 4**).

Phytochemicals: Mahmoodin, azadirone, epoxyazadiradione, nimbin, gedunin, azadiradione, deacetylnimbin, 17-hydroxyazadiradione, naheedin, azadirachtol, icosane, docosane, 2-methyltricosane, docosene (Siddiqui *et al*. 1992), azadirachtin A, B, D, H, I, desacetylnimbin, salanin, nimbolin, nimbinene, nimbolide (Sadeghian and Mortazaienezhad 2007), margolone, margolonone, isomargolonone, podocarpane (Ara *et al*. 1989), α-cubebene, copaene, humulene, 5-cadinene (Aromdee and Sriubolmas 2006), 11-epi-azadirachtin H, salannolide, quercetin-3-*O*-β-D-xyloside, quercetin-3-*O*-β-D-glucoside, kaempferol-3-*O*-β-D-glucoside, lutin, glycerin-1-monostearate, glycerin-1,3-distearate (Yin *et al*. 2005), desacetylnimbin, desacetylsalannin (Silva *et al*. 2007).

Ethnopharmacy: Tribals used plant parts to control leprosy, intestinal helminthiasis, respiratory disorders, constipation in the treatment of rheumatism, chronic syphilitic sores and indolent ulcer (Kirtikar and Basu 1935), to cure blood morbidity, biliary afflictions, itching, skin ulcers, burning sensations and inflammations (Tidjani *et al.* 1989).

Conservation measures: Salvi *et al.* (2001) and Venkateswarulu *et al.* (1998) reported plant regeneration of neem from different shoot explants using MS medium with 2 mg L^{-1} BAP and 0.1 mg L^{-1}. Eeswara *et al.* (1998) successfully produced micropropagated shoots from leaf explants on MS medium containing 1 mg L^{-1} BAP, 0.8 mg L^{-1} KN and 6 mg L^{-1} adenine hemisulphate (AH) in complete darkness. Somatic embryogenesis and plant regeneration from immature embryos was developed on MS medium with 0.5 mg L^{-1} of IAA, 1.0 mg L^{-1} BAP and 1000 mg L^{-1} of casein hydrolysate (CH) (Shrikhande *et al.* 1993). Similar to the above protocol somatic embryogenesis from cotyledons and hypocotyledons using MS agar medium with 0.5 mg L^{-1} BAP, 1 g L^{-1} CH and 50 g L^{-1} sucrose were developed by Su *et al.*

Table 4 *Azadirachta indica*: Medicinal uses, phytochemistry and ethnopharmacology.

Cytotoxic and genotoxic effects of aqueous extract.	Akinboro and Bakare 2007
Antiviral activity against white spot syndrome virus in shrimp.	Balasubramanian *et al*. 2007
Hypoglycemic responses in streptozotocin-induced diabetic rats.	Chandra *et al*. 2007
Anthelmintic efficacy and the homeopathic product Fator Vermes® in Morada Nova sheep.	Chagas *et al*. 2008
Neem Azal® (botanical) on survival and reproduction of the biting louse *Damalinia limbata* on angora goats.	Habluetzel *et al*. 2007
The toxic effects of neem extract and azadirachtin on the brown planthopper, *Nilaparvata lugens*.	Nathan *et al*. 2007
Cardioprotective on isoprenaline induced myocardial infarction in rats.	Peer *et al*. 2007
Enhanced production of azadirachtin by hairy root cultures by elicitation and media optimization.	Raji *et al*. 2007
Crude neem seed kernel extracts prevent infestation of *Sarcoptes scabiei* var. *Ovis*.	Tabassam *et al*. 2007
Antibacterial, antisecretory and antihemorrhagic activity, used to treat cholera and diarrhea in India.	Thakurta 2007
Acute lethal and sublethal effects of neem leaf extract on the neotropical freshwater fish *Prochilodus lineatus*.	Winkaler *et al*. 2007
Bark phenolic compoments have antioxidant activity.	Sultana *et al*. 2007
Anthelmintic activity.	Costa *et al*. 2006
Anti-plasmodial activity, used in traditional malaria therapy in Meru and Kilifi Districts of Kenya.	Kirira *et al*. 2006
Ethanolic neem leaf extract showed anticancer effect on prostate cancer cell line PC-3.	Kumar *et al*. 2006
Antifilarial activity on cattle filarial parasite *Setaria cervi*.	Mishra *et al*. 2005
Leaf mediated immune activation causes prophylactic growth inhibition of murine *Ehrlich carcinoma* and B16 melanoma.	Baral and Chattopadhyay 2004
Toxicity and repellence function for the protection of stored cowpea against *Callosobruchus maculates*.	Boeke *et al*. 2004
Safety evaluation of neem derived pesticides.	Dicke *et al*. 2004
Source of fertilizer/pesticide vermicompost.	Gajalakshmi and Abbasi 2004
Antiplaque activity of leaf extract.	Pai *et al*. 2004
Tetracyclic triterpenoids isolated from leaves.	Siddiqui *et al*. 2004
Neem from different provenances of India showed variability in triterpenoids nimbin and salanin.	Sidhu *et al*. 2004
Show natural weedicide function.	Xuan *et al*. 2004
Hepatoprotective activity.	Chattopadhyay 2003
Anthelmintic properties used as livestock dewormers by pastoralist and smallholder farmers in Kenya against *Heligmosomoides polygyrus* infections in mice.	Githiori *et al*. 2003
Inhibits *Lens* aldose reductase.	Halder *et al*. 2003
Used to treat common carp, *Cyprinus carpio*, for *Aeromonas hydrophila* infection.	Harikrishnan *et al*. 2003
Anthelmintic against gastrointestinal trichostrongylids in infected lambs.	Hördegen *et al*. 2003
Praneem Polyherbal vaginal tablet for HIV-uninfected women in Pune; Phase I safety study.	Joshi *et al*. 2004
Spermicidal activity is reported for leaf extract.	Khillare and Shrivastav 2003
Neem oil is useful for the control of pest, large pine weevil *Hylobius abietis* L.	Thacker *et al*. 2003

(1997). Multiple shoots were induced in neem by anther-derived callus when subcultured on MS medium augmented with 4.44 µM 6-benzyladenine (BA) + 0.53 µM NAA along with 18.75 µM polyvinylpyrrolidone (PVPP) (Gautam *et al*. 1993). Murthy and Saxena (1998) reported the mass propagation of neem by somatic embryogenesis which regenerated from embryos when cultured on MS medium supplemented with TDZ (20 µM). An alkaloid azadirachtin was isolated from seeds of neem (Bryan *et al.* 1986). Stem segments with buds from neem were used as explants in tissue culture for rapid propagation was established resulting in 100% of callus induction and a multiplication rate in the media MS + 1.0 mg L^{-1} BAP + 0.01 mg L^{-1} NAA + 3% sucrose for callus induction (Wei *et al.* 2004). *In vitro* morphogenesis from zygotic embryo cultures of neem was developed by Chaturvedi *et al*. (2004).

7. *Bacopa monnieri* (Linn.) Pennel - Scrophulariaceae

Trade name: Thyme leaved gratiola.

Threat status: Indeterminate.

Medicinal importance: The whole plant is used as a source of the Ayurvedic drug Brahmi (brahmighritam: epilepsy, hysteria), Source Brahmirasayanam, Sarasvataristam, Brahmitailam, Misrakasneham, astringent, diuretic, laxative, tonic for the heart and nerves, increases memory, intelligence, dermatosis, anaemia, diabetes, cough, fever, arthritis, anorexia, dyspepsia, emancipation, nerve tonic, cardiotonic and diuretic and the leaves are used to treat bronchitis, diarrhoea in children and the leaf paste is used to treat arthritis (www.ayushveda.com). Alters thyroid hormone concentrations in male mice (Kar *et al*. 2002), affects human memory (Roodenrys. *et al*. 2002) and mast cell stabilising activity (Samiulla *et al*. 2001).

Phytochemicals: Cucurbitacins (Bhandari *et al*. 2007) and bacosides 'A and B' are the putative major bioactive saponins (Deepak and Amit 2004). HPLC was used to separate the major triterpenoid saponins in *B. monnieri* (Ganzera *et al*. 2004), while ELISA used polyclonal antibodies against bacopaside (Phrompittayarat *et al*. 2000). Triterpenoid glycosides were found (Sivaramakrishna *et al*. 2005). Four cucurbitacins, bacobitacin A–D as well as a known cytotoxic, cucurbitacin E together with three known phenylethanoid glycosides, monnieraside I, III and plantioside B were isolated form the aerial part of the plant (Bhandari *et al*. 2007). Two triterpenoid glycosides have been isolated along with 10 known saponins. Structures of the compounds have been elucidated as 3-*O*-[β-D-glucopyranosyl-(1 → 3)-β-D-glucopyranosyl] jujubogenin and 3-*O*-[β-D-glucopyranosyl-(1 → 3)-β-D-glucopyranosyl] pseudojujubogenin. Further, the chemical compositions of bacosides A and B have been delineated (Sivaramakrishna *et al*. 2005).

Ethnopharmacy: Among the tribal inhabitants 5 leaves eaten daily for 1 month are believed to improve the speech of stutterers. The boiled leaves are applied to the abdomen to relieve post natal pains. The warm leaves are used as a poultice to relieve swellings following beatings (Das *et al.* 2002).

Conservation measures: Somatic embryogenesis was achieved by culturing apical and axillary buds on MS media supplemented with various combinations BAP, KN when combined with an auxin (Naik *et al.* 2007). Optimum adventitious shoot bud induction occurred on MS media supplemented with 300 mg L^{-1} bavistin from internode explants (Tiwari *et al.* 2006). Of the four cytokinins (BAP, KN, TDZ and 2-iP) tested 1-phenyl-3-(1,2,3-thiadiazol-5-yl) or thidiazuron (TDZ) (6.8 µM) and BAP (8.9 µM) proved superior to other treatments. Optimum adventitious shoot buds induction occurred at 6.8 µM TDZ where an average of 93 shoot buds were produced in leaf explants

after 7 weeks of incubation from node, internode and leaf explants. However, subculture of leaf explants on medium containing 2.2 µM BAP yielded a higher number (129.1) of adventitious shoot buds by the end of the third subculture. Better rooting response was observed on medium containing 4.9 µM IBA (Tiwari *et al.* 2001). Leaf explants gave the largest number of shoot buds followed by node and internode explants. BAP at 1.5-2.0 mg L^{-1} appeared to be optimum for inducing the maximum number of shoot buds. MS + 0.1 mg L^{-1} BAP + 0.2 mg L^{-1} IAA was the most suitable for shoot elongation. Elongated shoots were rooted on full- or half-strength MS medium with or without 0.5-1.0 mg L^{-1} IBA or 0.5-1.0 mg L^{-1} NAA. The rooted plants were successfully established in soil. Calli derived from nodal explants cultured on MS medium containing 0.5 mg L^{-1} 2,4-D, when subcultured on MS medium containing 0.1 or 0.5 mg L^{-1} BAP or 0.2 mg L^{-1} 2,4-D + 0.1 or 0.5 mg L^{-1} KN, developed somatic embryos. The somatic embryos germinated either on the same media or on MS basal medium and the resulting plantlets were successfully transplanted to soil (Tiwari *et al.* 1998).

8. *Bixa orellana* L. - Bixaceae

Trade name: Annatto plant.

Threat status: Indeterminate.

Medicinal importance: See **Tables 5** and **6**

Phytochemicals: Three minor carotenoids were isolated from the seed coat. The structures were established as 6-geranylgeranyl 8′-methyl-6,8′-diapocaroten-6,8′-dioate, 6-geranylgeranyl 6′-methyl (9′*Z*)-6,6′-diapocaroten-6,6′-dioate and 6-geranylgeranyl 6′-methyl-6,6′-diapocaroten-6,6′-dioate (Mercadante *et al*. 1999). Dimethyl (9*Z*,9′*Z*)-6,6′-diapocarotene-6,6′-dioate, methyl (9*Z*)-10′-oxo-6,10′-diapocaroten-6-oate, methyl (9*Z*)-6′-oxo-6,5′-diapocaroten-6-oate and methyl (4*Z*)-4,8-dimethyl-12-oxo-dodecyl-2,4,6,8,10-pentaenoate are new compounds, whereas methyl bixin and methyl (9*Z*)-8′-oxo-6,8′-diapocaroten-6-oate have previously been isolated (Mercadante *et al*. 1997). Leaf oil contains a compound known as Ishwarone (Lawrence and Hogg 1973).

Ethnopharmacy: Among tribals the decoction of the leaves is used as a gargle to treat sore throats while an infusion is given in case of jaundice and dysentery. Moreover a poultice of the leaves is applied to cuts and gashes as a scar preventative. The pounded leaves macerated in water release a gummy substance that is diuretic and prescribed in cases of gonorrhoea (Fleischer *et al.* 2003).

Table 5 *Bixa orellana*: Plant parts and their medicinal importance (Parrotta 2001).

Part used	Response
Pulp surrounding the seeds	Haemostatic, antidysentric, diuretic, laxative, febrifuge, digestive, epilepsy, kidney, skin diseases, prevents blisters and scars (fresh pulp).
Fruit	Antidote to poisoning.
Seeds	Astringent, febrifuge, gonorrhea, leprosy (seed oil).
Leaves	Febrifuge, anti-tumour.
Twigs	Liver disorders as an emollient.
Root bark	Antiperiodic, treats fevers.
Fruit	Haemostatic, antidysentric, diuretic, laxative, febrifuge, digestive, epilepsy, kidney, skin diseases, prevents blisters and scars (fresh pulp).
Seeds	Antidote to poisoning.
Leaves	Astringent, febrifuge, gonorrhea, leprosy (seed oil).
Twigs	Febrifuge, anti-tumour.
Root bark	Liver disorders as an emollient.

Conservation measures: See **Table 7**.

9. *Boswellia serrata* Roxb. ex Colebr. - Burseraceae

Trade name: White Dammar.

Threat status: Indeterminate.

Medicinal and pharmaceutical importance: See **Tables 8** and **9**.

Phytochemicals: 11-keto β-boswellic acid (Sharma *et al*. 2004), two new triterpenoids, 2α,3α-dihydroxy-urs-12-ene-24-oic acid and urs-12-ene-3α,24-diol, have been isolated from the gum resin (Mahajan *et al*. 1995). 4-*O*-methyl-glucuronoarabino-galactan (Sen *et al*. 1992) was isolated from the plant.

Table 6 *Bixa orellana*: Medicinal uses, phytochemisttry and ethnopharmacology.

DNA damage and aberrant crypt foci as putative biomarkers to evaluate the chemopreventive effect of annatto in rat colon carcinogenesis.	Agner *et al*. 2005
Antileishmanial and antifungal activity of plants used in traditional medicine in Brazil.	Bautista *et al*. 2007
Stability of bixin in annatto oleoresin and dye powder during storage.	Balaswamy *et al*. 2006
Preliminary pharmacological screening of leaves.	Shilpi *et al*. 2006
Evaluation of the clastogenicity and anticlastogenicity of the carotenoid bixin in human lymphocyte cultures.	Antunes *et al*. 2005
Bixin and α-cyclodextrin inclusion complex and stability tests.	Lyng *et al*. 2005
Effect of processing conditions on the stability of annatto dye incorporated into some foods.	Rao *et al*. 2005
The use of nonlinearity measures to discriminate the equilibrium moisture equations for seeds.	Ribeiro *et al*. 2005
Nutrient fluxes in rainfall, throughfall and stemflow in tree-based land use systems and spontaneous tree vegetation of central amazonia.	Schroth *et al*. 2001
Carcinogenic and anticarcinogenic effects of annatto in the rat liver medium-term assay.	Agner *et al*. 2004
Study on the mutagenicity and antimutagenicity of a natural food colour (annatto) in mouse bone marrow cells	De Lima *et al*. 2003
Antimicrobial activity of the leaves and seeds.	Fleischer 2003
A thirteen-week oral toxicity study of annatto extract (norbixin), a natural food color extracted from the seed coat of annatto in Sprague–Dawley rats.	Imai 2003
Norbixin ingestion did not induce any detectable DNA breakage in liver and kidney but caused a considerable impairment in plasma glucose levels of rats and mice.	Fernandes 2002
Probing carotenoid biosynthesis in developing seed coats through expressed sequence tag analysis.	Jako 2002
Evaluation of the developmental toxicity of annatto in the rat	Paumgartten *et al*. 2002
Differential expression of 3-hydroxy-3-methylglutaryl-CoA reductase (HMGR) during flower and fruit development.	Narváez *et al*. 2001
Medicinal plants used for dogs in Trinidad and Tobago.	Lans *et al*. 2000
Snakebites and ethnobotany in the northwest region of Colombia: Neutralization of lethal and enzymatic effects of *Bothrops atrox* venom.	Núñez *et al*. 2000
Snakebites and ethnobotany in the northwest region of Colombia: Neutralization of the haemorrhagic effect of *Bothrops atrox* venom.	Otero *et al*. 2000

Table 7 *Bixa orellana*: Conventional and biotechnological studies on propagation

Explant	Medium composition	Organogenic response	Reference
Hypocotyl	MS + 0.56 μM Z, 87.6 mM sucrose, and 2.8 g L^{-1} phytagel.	Multiple shoots	de Paiva *et al*. 2003
Shoot apex and nodal segments	0.9 μM 2-iP.	Multiple shoots	D'Souza and Sharon 2001
Shoot apex and nodal segments	B5 medium supplemented with 1.0 mg L^{-1} 2-iP.	Multiple shoots	Sharon and D'Souza 2000

Abbreviations: 2-ip: N^6-(2-isopentenyl)adenine; B5: Gamborg's medium; Z: zeatin.

Table 8 *Boswellia serrata*: Uses of phytochemicals and pharmacological response.

Part used	Response	Reference
Oleo gum resins (α-thujene)	Anti inflammatory.	Singh *et al*. 2007
Oleo gum resins (3α-acetyl-11-keto-α-boswellic acid)	Anti cancererous.	Buchele *et al*. 2006
Extract is known to contain 11-keto-β-boswellic acid (KBA) and acetyl-11-keto-β-boswellic acid (AKBA)	Anti inflammatory.	Pozharitzkaya *et al*. 2006; Gayathri *et al*. 2007
Bark is reported to have 20,24 dihydroxyeupha-2,8,22-triene (1) and 5(6)-ene, 26-hydro-xyoctacosanoic acid	Anti inflammatory.	Singh and Bakuni 2006
Gum (bark)	Incense, astringent, stimulant, expectorant, diuretic, diaphoretic, emmenagogue, ecbolic, antiseptic, ulcers, tumours, goitre, breast cysts, diarrhoea, dysentery, piles and skin diseases, ointment for sores.	Parrotta 2001
Gum + butter	Syphilis.	Parrotta 2001
Non phenolic fraction (oleo-gum resin)	Anti tumour, sedative, analgesic.	Parrotta 2001
Bark	Diarrhoea, piles, skin diseases, ulcers, coughs.	Parrotta 2001

Table 9 *Boswellia serrata*: Bioactive compounds, phytochemisttry and ethnopharmacology.

Screening of plant extracts for antimicrobial activity against bacteria and yeasts with dermatological relevance.	Weckesser *et al*. 2007
Estimation of boswellic acids from market formulations of *B. serrata* extract and 11-keto β-boswellic acid in human plasma by high-performance thin-layer chromatography.	Shah *et al*. 2007
Efficacy and tolerability of *B. serrata* extract in treatment of osteoarthritis of knee – A randomized double blind placebo controlled trial.	Kimmatkar *et al*. 2003
Boswellic acids activate p42 MAPK and p38 MAPK and stimulate Ca^{2+} mobilization.	Altmann *et al*. 2002
Antioxidant activity of natural resins and bioactive triterpenes in oil substrates.	Khajuria *et al*. 2005
A new vaccine adjuvant (BOS 2000) a potent enhancer mixed Th1/Th2 immune responses in mice immunized with HBsAg.	Suri *et al*. 2007
A chemical investigation by headspace SPME and GC–MS of volatile and semi-volatile terpenes in various olibanum samples.	Hamm *et al*. 2005

Ethnopharmacy: The tribals chew the stem bark to relieve toothache and to check pus formation in the mouth. A luke-warm paste of the bark is applied externally to relieve eye inflammations. A decoction of the stem bark is taken to treat dysuria, and a paste of the dried, ground bark is applied to the forehead to relieve headache. Pounded together with turmeric in kerosene, it is applied to relieve traumatic pain. The powdered flowers are used to treat colds and fevers. The tree also yields a valuable timber (Jain *et al*. 2005).

10. *Butea monosperma* (Lam.) Taub. - Fabaceae

Trade names: Flame of the forest; Bengal king.

Threat status: Endangered (Jadhav *et al.* 2001).

Medicinal importance: The medicinal importance of *B. monosperma* is depicted in **Tables 10** and **11**.

Phytochemicals: Apart from stigmasterol, stigmasterol-β, D-glucopyranoside and nonacosanoic acid, two new compounds were isolated from the stems and have been characterised as 3α-hydroxyeuph-25-ene and 2,14-dihydroxy-11, 12-dimethyl-8-oxo-octadec-11-enylcyclohexane (Mishra *et al*. 2007). A new imide, palasimide, was isolated from the pods and identified as palasonin-*N*-phenyl imide (Guha *et al*. 1990).

Ethnopharmacy: The tribals use the juice of the stem bark in the treatment of dysentery. The bark extract is taken with water as a remedy for fevers. A decoction of the bark is prescribed for coughs, colds, fever, various forms of haemorrhages, in menstrual disorders and is used in the preparation of tonics and elixirs. The filtrate of the boiled stem bark is used as a bath for patients suffering from jaundice. The roots ground with water to form a paste are applied to the chest to relieve congested lungs. Raw leaf extract is used to treat diarrhoea. An extract of the crushed leaves, mixed with the tender leaves of *Ricinus communis* is used to treat jaundice. A paste of the flowers is applied to the chest to relieve asthma, and the water in which flowers are soaked overnight is used to relieve sunstroke. Also used as an emmenagogue and as a poultice to relieve orchitis, swellings and sprains. It is also considered effective for the treatment of leprosy, leucorrhoea and gout. A cool infusion of the flowers is taken in the treatment of diabetes. A decoction of the petals is given to treat diarhoea and to puerperal women. The expressed juice from the flowers or an infusion of the flowers is given to treat diarrhoea and dysentery among the tribal inhabitants. The seeds are useful for treating flatulence and piles. Pounded with lemon juice the seeds act as powerful rubefacient and are used to cure ringworm and other skin diseases. The powdered seeds are given to remove intestinal worms among the tribal inhabitants and for treating amenorrhea by tribal women. An extract of the leaves, seeds and flowers is reputed to have contraceptive properties (Kala *et al.* 2004).

Table 10 *Butea monosperma*: Medicinal importance of its parts and constituents (Parrotta 2001).

Part used	Application to health disorder
Gum	Medicinal properties, astringent, diarhoea, dysentery.
Gum infusion	Leucorrhoea.
Solution of gum	Bruises, erysipelatous inflammations and ringworm.
Stem bark	Astringent, bitter, acrid, alterative, aphrodisiac, anthelmintic.
Ayurveda	Bone fractures, ulcers, tumours, colic, intestinal worms, bleeding piles, dysentery, haemorrhages, amenorrhoea, dysmenorrhoea, gonorrhoea, eye diseases.
Roots	Elephantiasis, night blindness, causes temporary sterility.
Root bark	Aphrodisiac, analgesic, anthelmintic, spruce, piles, ulcers, tumours, dropsy.
Leaves	Astringent, tonic, diuretic, aphrodisiac.
Unani	Boils, pimples, tumorous haemorrhoids, colic, worms, piles.
Flowers	Astringent, diuretic, depurative, aphrodisiac, tonic.
Bark	Insecticide against house flies.

Table 11 *Buta monosperma*: Bioactive compounds and ethnopharmacological studies.

Anti-inflammatory activity of its flowers.	Shahavi and Desai 2007
Antidiabetic potential.	Somani *et al*. 2006
In vivo anthelmintic activity.	Iqbal *et al*. 2006
Chemomodulation: Protective role against thioacetamide-mediated hepatic alterations in Wistar rats.	Sehrawat *et al*. 2006
Dermal wound healing function in rats.	Sumitra *et al*. 2005
Anti-diarrhoeal activity.	Gunakkunru *et al*. 2005
Dispersion and diversity along a disturbance gradient in a dry tropical forest region of India.	Sagar *et al*. 2003
Comparative efficacy of three epigeic earthworms under different deciduous forest litter decomposition.	Manna *et al*. 2003
Anticonvulsive activity.	Kasture *et al*. 2002
Anthelmintic activity.	Prashanth *et al*. 2001
High nutritive value, multipurpose tree species.	Ramana *et al*. 2000
Euphane triterpenoid and lipid constituents.	Mishra *et al*. 2000
Anticonvulsive activity.	Kasture *et al*. 2000
Useful for Lac production.	Sequeira and Bezkorowajnyj 1998
Management of Giardiasis by herbal drug 'Pippali Rasayana': A clinical study.	Agrawal *et al*. 1994, 1997
Isolation and properties of a lectin from the seeds.	Wongkham *et al*. 1994
An imide has been characterized from the pods.	Guha *et al*. 1990
Sten bark had antifungal constituents.	Ratnayake *et al*. 1989
Estrogenic and postcoital anticonceptive activity.	Bhargava 1986
Contains glucosides.	Gupta *et al*. 1970

Table 12 *Butea superba*: Medicinal importance of its plant parts (Parrotta 2001).

Part used	Medicinal use and response
Leaf juice + curd + yellow zedoary	Heat eruptions in children.
Seeds	Sedative and anthelminthic.
Seeds + stem decoction	Emollient, treats piles.
Seed oil	Anthelminthic and hypotensive.
Gum	Tonic and poultice.

11. *Butea superba* Roxb. - Fabaceae

Trade names: Butea; Red Kwao Krua.

Threat status: Indeterminate.

Medicinal importance: It is reported to contain cytotoxic constituents (Ngamrojanavanich *et al*. 2007a, 2007b). Butenin is the main constituent and is reported to be toxic to rats. This plant has been inuse in Thai folklore medicine for over 100 years for increasing vitality, rejuvenation and in the treatment of impotence in men (Manosroi *et al*. 2006). It showed differential anti-proliferation effect on the growth of MCF-7 cells (an estrogen receptor positive (ER+) human mammary adenocarcinoma) (Cherdshewasart *et al*. 2004). One of the most promising treatments of Alzheimer's disease (AD) is to enhance the acetylcholine level in the brain by administering acetylcholinesterase (AChE) inhibitors from the stem of *B. superba* (Ingkaninan *et al*. 2003). See also **Table 12**.

Phytochemicals: 3-hydroxy-9-methoxypterocarpan, 7-hydroxy-4′-methoxy-isoflavone, 7,4′-dimethoxyisoflavone, 5, 4′-dihydroxy-7-methoxy-isoflavone, 7-hydroxy-6,4′-dimethoxyisoflavone, butesuperins A and B, isoflavonolignans (Ma *et al*. 2005), 3,5,7,3',4'-pentahydroxy-8-methoxy-flavonol-3-*O*-β-D-xylopyranosyl(1→2)-α-L-rhamnopyranoside (Yadava and Reddy 1998a), 3,7-dihydroxy-8-methoxyflavone 7-*O*-α-L-rhamnopyranoside (Yadava and Reddy 1998b).

Ethnopharmacy: The tribals use the paste of the stem bark to treat haematuria. The roots are ground with water and applied externally for relief of weeping eczema. In Ayurveda the bark, flower, seed and resin is used as a substitute for those of *Butea monosperma* (Parrotta 2001).

12. *Centella asiatica* (L.) Urb. - Apiaceae

Trade name: Indian penny wort.

Threat status: Indeterminate.

Medicinal importance: The medicinal and phytochemical importance of different parts is described in **Table 13**.

Ethnopharmacy: Tribals use the extract of the plant in wound healing and it also shows anti inflammatory properties thus reduces eczema (Dweck *et al*. 2002).

Conservation measures: The cost effectiveness in terms of ingredients of media like sucrose, agar and distilled water was studied by Raghu *et al.* (2007) and proved to be very effective during micropropagation. High frequency bud break (88%) and multiple shoot formation (16.8) were induced from a shoot tip, which was cultured on MS medium supplemented with BAP (17.76 μM) and GA_3 (1.44 μM). Half-strength MS medium supplemented with NAA (10.74 μM) induced the maximum (27.66) number of roots (Sivakumar *et al*. 2006). Nodal segments when cultured on MS media supplemented with BAP (2.0 mg L^{-1}) and NAA (1.0 mg L^{-1}) induced multiple shoot regeneration. *In vitro* rooting was induced when MS medium was supplemented with IAA (1.0 mg L^{-1}) (Shashikala *et al*. 2005). Various conservation measures are depicted in **Table 14**. Work carried out during 2001-2004 field seasons resulted in many plants being collected from 15 different locations of Andhra Pradesh and planted in the field experimental site at the University of Hyderabad Campus. Germplasm in the form of seeds was stored in a seed bank. Studies on diversity analysis were carried out for accessions collected from various locations. The plant is propagated vegetatively.

13. *Celastrus paniculatus* Willd. - Celastraceae

Trade name: Intellect tree.

Threat status: Nearly threatened (www.iucn.org).

Medicinal uses: Leaves and roots are reported to cure headache and leaves with *Centella asiatica* leaf paste used as a nerve tonic (Parrotta 2001). The seeds are used for sharpening memory, asthma, gout, aphrodisiac, cardiotonic, laxative prutitis, ulcers, stomach disorders and oedema (Nadakarni 1976). Seed oil has been reported to exert pharmacological actions like anti-malarial, anti-bacterial, anti viral, insecticidal and hypolipidemic and treating in diseases like urinary infections, body pains, skin infections, anti convulsant, muscle relaxant, wound healing, rubefacient, scabies (Ayudhaya *et al.* 1987; Khanna *et al.* 1991) (**Table 15**).

Medicinal importance and phytochemicals: Methanolic extracts of *C. paniculatus* plant material was shown to have free-radical scavenging effects, and was also capable of reducing hydrogen peroxide (H_2O_2) induced cytotoxicity and

Table 13 *Centella asiatica*: Medicinal and phytochemical importance from different parts.

Part used	Phytochemical	Response	Reference
Aerial parts	Triterpene, saponin	-	Yu *et al*. 2007
Leaves	-	Antioxidant.	Gnanapragasam *et al*. 2007
Whole plant extract and powder	-	Antioxidant.	Hussain *et al*. 2007
Whole plant	Asiaticoside	Anxiolytic, epilepsy, hoarseness, asthma, bronchitis, hicough, abdominal disorders, fever, anxiety, minor memory disturbances, psychotropic agent, memory enhancer, general debility, jaundice, leprosy.	Wijeweera *et al*. 2006
Whole plant	-	Cytotoxic.	Steenkamp and Gouws 2006
Whole plant	Triterpenoids	Effects methyl jasmonate pathway.	Mangas *et al*. 2006
Whole plant	-	Learning and memory enhancer.	Sulochana *et al*. 2005
Whole plant extract	-	Neurological disorders.	Subathra *et al*. 2005
Plant extract	Pectin	Immulogical activity.	Wang *et al*. 2005
Plant extract	Arabinogalactan	Immunoactive.	Wang *et al*. 2005
Plant extract	Asiatic acid	Apoptosis.	Park *et al*. 2005
Whole plant	-	Phytoremediation.	Park *et al*. 2005
Whole plant	-	Cytotoxic, anti-tumour.	Caldas and Machado 2004
Leaf extract	-	Immunomodulatory.	Babu *et al*. 1995
Oil extract from leaves	-	Anti bacterial.	Jayathirtha and Mishra 2004

Table 14 *In vitro* clonal multiplication of *Centella asiatica* carried out using different explants by various groups.

Explant	Medium composition	Culture type	Reference
Shoot tip	Half-strength MS medium supplemented with NAA (10.74 μM).	Multiple shoots	Sivakumar *et al*. 2006
Nodal segments	MS supplemented with BAP (2.0 mg L^{-1}) + NAA (1.0 mg L^{-1}).	Multiple shoots	Shashikala *et al*. 2005
Leaf segments	MS with 9.29 μM kinetin in combination with 2.26 μM 2,4-D.	Multiple shoots	Paramageetam *et al*. 2004
Leaf petiole, leaf lamina, internodal explants	MS with 4.52 μM 2,4-D + 2.32 μM KN; MS + 5.37 μM NAA + 2.32 μM KN.	Multiple shoots	Martin 2004b

Abbreviations: 2,4-D: 2,4-dichlorophenoxy acetic acid; BAP: 6-benzylaminopurine; KN: kinetin; MS: Murashige and Skoog (1962) medium; NAA: α-naphthaleneacetic acid.

Table 15 *Celastrus paniculatus*: Bioactive compounds, phytochemical and phamacological investigations

Evaluation of anxiolytic potential of its oil in rat models.	Rajkumar *et al.* 2007
Seed oil and organic extracts attenuate hydrogen peroxide- and glutamate-induced injury in embryonic rat forebrain neuronal cells.	Godkar *et al.* 2006
Seed water soluble extracts protect cultured rat forebrain neuronal cells from hydrogen peroxide-induced oxidative injury.	Godkar *et al.* 2003
Seed water soluble extracts protect against glutamate toxicity in neuronal cultures from rat forebrain.	Godkar *et al.* 2003
Antioxidant property, a possible mechanism in enhancing cognition.	Kumar and Gupta 2002
Indian medicinal plants as antiradicals and DNA cleavage protectors.	Russo *et al.* 2001
Production and partial purification and characterization of a thermo-alkali stable polygalacturonase from *Bacillus* sp. MG-cp-2 process.	Kapoor *et al.* 2000
Sesquiterpenes.	Kun *et al.* 1998
Effects of *C. paniculatus* on passive avoidance performance and biogenic amine turnover in albino rats.	Nalini *et al.* 1995
Preliminary screening of methanolic extracts of *C. paniculatus* and *Tecomella undulata* for analgesic and anti-inflammatory activities.	Ahmad *et al.* 1994
Dihydroagarofuran sesquiterpenoids from *C. paniculatus*.	Sang *et al.* 1991
Antispermatogenic action of *C. paniculatus* seed extract in the rat with reversible changes in the liver.	Bidwai *et al.* 1990
Quinone-methide, phenolic and related triterpenoids of plants of Celastraceae: Further evidence for the structure of Celastranhydride.	Gamlath *et al.* 1990
Effect of *C. paniculatus* seed extract on the brain of albino rats.	Bidwai *et al.* 1987
Reversal of scopolamine-induced deficits in navigational memory performance by the seed oil.	Gattu *et al.* 1997
Configuration of malkanguniol.	Lotter *et al.* 1978
Stuctural elucidation of sesquiterpene-esters and sesquiterpene-alkaloids.	Wagner *et al.* 1975
Structure and stereochemistry of sesquiterpene-esters and sesquiterpene-alkaloidse.	Wagner *et al.* 1975

DNA damage in human non-immortalized fibroblasts (Russo *et al*. 2001). Anti-spermatogenic and antifertility effect of *C. paniculatus* seed extract on the testis of albino rats was reported by Wangoo and Bidwai (1988) and Bidwai *et al*. (1990). *C. paniculatus* seed oil (96% alcoholic emulsion) showed antibacterial activity against Gram-positive and Gram-negative bacteria (Khare 2004). Chloroform extracts of seed extract gave a pentacyclic terpene "pristimerin" which was found to have antiplasmodial activity (Mahidol *et al*. 1994). Phytochemical investigations of *C. paniculatus* sub sp. *paniculatus* seed oil revealed the presence of crystal structure of "malkanguniol". Two new β-dihydroagarofuran sesquiterpene polyol esters "celapanine" and "celapanigine" were deduced on the basis of spectral analysis from *C. paniculatus* (Zhang *et al*. 1998). The aqueous seed extracts of *C. paniculatus* improved the learning and memory in rats by both the shuttle-box and step-through paradigms (Karanth *et al*. 1980, 1981; Kumar and Gupta 2002). Nalini *et al*. (1995) reported the active principles using seed oil of *C. paniculatus*, which decreased the turnover of all the three central monoamines norepinephrine (NE), dopamine (DA) and serotonin (5-HT), implicating the involvement of aminergic systems in the learning and memory process of rats. The seed oil induces a feeling of well-being and is reported to have aphrodisiac effects. It acts as a powerful brain tonic to stimulate intellect, sharpen memory and increase intelligence and it also produces improvements in mentally retarded children without any lethal or neurotoxic effects (Nalini *et al.* 1986). The seed oil is reported to be beneficial in the treatment of mental conditions of psychiatric patients and also helpful in increasing memory performance in individuals who are cognitively impaired as a result of chemical or organic brain damage as compared with normal subjects (Gattu *et al*. 1997).

Ethnopharmacy: Tribals used the root powder with rice water and black pepper in treating spermatorrhoea, leucorrhoea and piles and the bark used as an abortifacient and

depurative. And they used the leaves in opium poisoning and deaddiction aid (Parrotta 2001).

Conservation measures: An efficient system of rapid *in vitro* multiplication and field restoration of *C. paniculatus* by using different explants, excised from young vines of the flowering woody climber was successfully established by Nair and Seeni (2001). The maximum number (3.6) and frequency (94%) of axillary shoot formation was noticed when nodes were cultured on MS medium supplemented with BAP (1.0 mg L^{-1}), compared to other hormone concentrations after 6 weeks. Rooted plants were established with a success rate of 84-96%. Successful regeneration of plantlets via cotyledonary leaf derived callus cultures in *C. paniculatus* on MS medium supplemented with NAA (5 µM) and KN (5 µM) with a doubling time of 16.2 days and well developed multiple shoots could be obtained via organogenesis within 28 days on MS + BAP (0.2 µM) were achieved with an 80% survival rate by Sharada *et al*. (2003). Multiple shoot bud induction directly from internode explants of *C. paniculatus* on MS medium containing BAP (2.22 µM) was achieved by Rao and Purohit (2006). Another efficient micropropagation protocol using nodal explants on MS medium with 1.5 mg L^{-1} BAP and 0.1 mg L^{-1} NAA were reported by Martin *et al*. (2006). High frequency shoot multiplication of *C. paniculatus* using seed explants on MS medium with 4.4 µM BAP + 1.1 µM KN was reported by Raju and Prasad (2007a). In strengthening its conservation management practices, genetic diversity analysis of *C. paniculatus* with high polymorphism (91%) using Random Amplified Polymorphic DNA (RAPD) markers was reported by Raju and Prasad (2007b).

14. *Chlorophytum arundinaceum* Baker. - Liliaceae

Trade name: Musli.

Threat status: Endangered (Jadhav *et al*. 2006).

Medicinal importance: The tubers are medicinally used to treat nervous disorders and used as a general tonic for strength and vigour. The decoction of the root along with turmeric powder is used to treat rheumatism. The root is also used to treat sprue, piles, blood disorders and as an aphrodisiac and rejuvenator. The tubers are also used in the preparation of tonics (Sumy *et al*. 2000; Parrotta 2001). The plant extract is used to treat gastric ulcers (Rachchh *et al*. 2004). The phytochemicals saponins act as anti cytotoxic against cancer cell lines (Kaushik 2005).

Phytochemicals: The chemical constituents present in the roots include 2′,4,4′-trihydroxy-2-xylopyranosyl (bibenzyl), 4-hydroxy-8,11-oxidoheneicosanol, pentacosyl docosanoate, stigmasterol, stigmasterol-β-D-glucopyranoside, nonacosane, tetracosanoic and triacontanoic acids (Tandon *et al*. 1992; Tandon and Shukla 1993).

Ethnopharmacy: The fried root powder is chewed to heal ulcers of the mouth and throat.

Conservation measures: *In vitro* clonal multiplication of *C. arundinaceum* was carried out using different explants by various groups. The shoot crown was used as an explant on the combination MS + 4 µM KN and 2 µM IBA (Lattoo *et al*. 2006).

15. *Chlorophytum tuberosum* (Roxb.) Baker - Liliaceae

Trade name: Safed musli.

Threat status: Threatened mainly due to commercialization and overexploitation.

Medicinal and phytochemical importance: The tuberous roots are used to treat non-hormonal restorative tonic (men and women), tonic against fatigue, weakness, general debility and the tubers are used to treat leucorrhoea. The antioxidant potential of *C. tuberosum* has been investigated for its ability to scavenge 1,1,diphenyl picryl hydrazyl (DPPH), a nitric oxide radical along with their capacity to reduce lipid peroxidation in rat liver homogenate, chelation of ferrous ion, radical scavenging potential using chemiluminescence and their total antioxidant capacity. Sugar, starch, protein, and Vitamin C content were estimated spectrophotometrically along with the percentages of the individual amino acids by HPLC and individual sugars by using HPTLC as standardization tool. The extract possessed antioxidant activity in all the models tested as evident by IC_{50} values: 225.31, 888.44, 809.22 and 422.97 µg mL^{-1} for scavenging of DPPH, nitric oxide, lipid peroxidation and ferry bi-pyridyl complex, respectively, along with an integral antioxidant activity of 2.986 nmol ascorbic acid/g equivalents in a photochemiluminescence assay (Narsimhan *et al*. 2006).

A field survey of the Sitamata wildlife sanctuary was carried out by Jain *et al*. (2005) during 2002-2004 to document the medicinal utility of herbs. Two hundred and fourty-three genera belonging to 76 families were reported which are used by the tribals of about 50 villages around the Sitamata wildlife sanctuary as means of primary health care to cure various ailments. The study revealed the new ethnobotanical uses of 24 plant species belonging to 20 genera. A list of plant species along with their local name, plant part(s) used and mode of administration for effective control in different ailments of ethnomedicinal plants was compiled by Jain *et al*. (2005).

Ethnopharmacy: Tribals use the extract of the roots crushed in rice water to cure dysmenorrhoea (Batugal *et al.* 2004).

Conservation measures: Germplasm in the form of plants and tubers was collected from various locations of Andhra Pradesh and grown in a field gene bank and also stored in the gene bank.

16. *Commiphora wightii* (Arnott.) Bhand. - Burseraceae

Trade name: Guggul.

Threat status: Endemic and endangered (Kumar and Shankar 1982).

Medicinal and phytochemical importance: Gum resin of this species is the famous "guggal" of trade. It is reported to be an astringent, antiseptic and aphrodisiac. It is also employed for treatment of snake-bite and scorpion sting (Sumy *et al*. 2000), treatment of hyperlipidaemia and atherosclerosis (Satyavati 1990; Kumar *et al*. 1997), urinary infections, ascites, piles, fistula, swelling, ulcers and pains (Anonymous 1976; Kumar *et al*. 1997); antiplasmodial activity, hypochloesteromic, anti-septic, anti-pathogenic, anti-parasitic properties, diarrhoea, dysentery (Sharma and Sharma 1996, 2001), anti-inflammatory activities (Duwiejua *et al*. 1993); antihyperlipoproteinemic (Dev 1999), arthritis, rheumatism, hypercholesterolemia (Kumar and Shankar 1982). Guggulsterone-M, guggulsterols I, guggulsterols Y, myrrhanol A, myrrhanone A, *Z*- and *E*-guggulsterones (Meselhy 2003). Bioactive constituents were reported from gum guggul (Zhu *et al*. 2001). Oleogum resin showed *in vitro* schizontocidal activity with *Plasmodium falciparum* (Sharma and Sharma 2001). Nitric oxide (NO) is associated with oxidative stress and with the pathophysiology of various diseases such as rheumatoid arthritis, diabetes, cardiovascular diseases, and chronic inflammation, cytokines and other inflammatory stimuli such as bacterial lipopolysaccharides (LPS). NO is synthesized from L-arginine. The methanolic extract of the oleogum resin of *C. wightii* demonstrates potent inhibitory activity of NO production in LPS-activated

murine macrophages (Meserlhy 2003). A lotion prepared from its stem bark is used to treat skin conditions such as impetigo, eczema and shingles. Many related phytochemicals were found viz., dammarane triterpenes), ferulates, furanosesquiterpenes, mansumbinane derivatives, steroids, lanostenols, sesquiterpenes, oxygenated alkanes, guggulsterones, guggutetrols and lignans. An antifungal flavanone, muscanone (1), and known naringenin (2) from the air-dried trunk showed bioactivity on *Candida albicans* (Fatope *et al*. 2003).

Conservation measures: Somatic embryogenesis in callus cultures of *C. wightii* was achieved (Singh *et al*. 1997; Kumar *et al*. 2003). Though the frequency of explants producing embryonic culture was low, immature zygotic embryos were the only suitable explants to produce embryonic callus after reciprocal transfers on media containing 2,4,5-trichlorophenoxy acetic acid (0.1 mg L^{-1}) and KN (0.1 mg L^{-1}) or devoid of growth regulators. Embryonic cells were small, densely filled with cytoplasm and isodiametric as compared to non-embryonic cells, which were large, elongated and vacuolated. Maximum growth of embryonic callus was recorded on modified MS medium supplemented with BAP (0.25 mg L^{-1}) and IBA (0.1 mg L^{-1}). Modified MS supported higher growth of callus as compared to tissues grown on B5 medium containing the same concentrations of plant growth regulators. Exogenous medium nutrients had no effect on somatic embryo development whereas plant growth regulators had little effect. Resin canals form in somatic embryos of *C. wightii* (Kumar *et al*. 2004). Tanwar *et al*. (2007) studied the effect of morphactin on the production of guggulsterone in callus cultures. Vegetative propagation through cuttings is possible (Kumar *et al*. 2004).

17. *Costus speciosus* Sims. - Zingiberaceae

Trade name: None.

Threat status: Vulnerable (Ravikumar and Ved 2000; Sumy *et al*. 2000; Reddy *et al*. 2001).

Medicinal uses: The rhizomes are bitter, astringent and reported to be useful in burning sensation, flatulence, constipation, helminthiasis, leprosy, skin diseases, fever, hiccough, asthma, bronchitis, inflammations, purgative, depurative, stimulant, anaemia anthelmintic, aphrodiaiac, astringent, digestive, to cure dropsy, fever, skin diseases, worm troubles, sterilization, dyspepsia, diabetes, leprosy, rheumatism and limbago, eye, skin and urinary diseases, mental disorders (Rao *et al*. 1999; Sumy *et al*. 2000; Parrotta 2001); insecticidal activity (Pipithsangchan and Morallo-Rejesus 2005).

Phytochemicals: Diosgenin (Dasgupta and Pandey 1970; Pipithsangchan and Morallo-Rejesus 2005), furostanol glycoside 26-*O*-β-glucosidase (F26G) (Inoue and Ebizuka 1996), β-sitosterol-β-D-glucopyranoside, prosapogenin-B of dioscin, prosapogenin-A of dioscin, dioscin, gracillin, 3-*O*-[α-L-rhamnopyranosyl (1→2)-β-D-glucopyranosyl], 26-O-[β-D-glucopyranosyl]-22α-methoxy-(25R)-furost-5-en-3β, 26-diol, methyl protodioscin, costusoside I, costusoside J and protodioscin (Singh and Thakur 1982), methyl protodioscin, methyl protogracillin, protogracillin, furostanol monoglycoside, 26-*O*-β-D-glucopyranosyl-(25R)-furost-5-ene-3β, 22ζ, 26-triol, diosgenin 3-*O*-β-D-glucopyranosyl (1→3)-β-D-glucopyranoside, β-glucosidase (Inoue *et al*. 1995, 1996), Saponins B, C, gracillin and dioscin (Tschesche and Pandey 1978), 5α-stigmast-9(11)-en-3β-ol (Madan *et al*. 1981), 24-hydroxyhentriacontan-27-one, 24-hydroxytriacontan-26-one, methyl triacontanoate, diosgenin, sitosterol, 8-hydroxytriacontan-25-one, methyl tritriacontanoat, tetradecyl 13-methylpentadecanoate, tetradecyl 11-methyltridecanoate, 14-oxotricosanoic acid, 14-oxoheptacosanoic acid, 15-oxo-octacosanoic acid, triacontanol, 5α-stigmast-9 (11)-en-3β-ol, triacontanoic acid, sitosterol and diosgenin (Gupta *et al*. 1981a, 1981b, 1981c, 1981d, 1982, 1986), α-tocopherolquinone and 5α-stigmast-9(11)-en-3β-ol, 6-methyl dihydrophytylplastoquinone (2,5,6-trimethyl-3-(3,7,11, 15-tetra-methylhexadecyl)-1,4-benzoquinone), dihydrophytylplastoquinone (5,6-dimethyl-3-(3,7,11,15-tetramethyl hexadecyl)-1,4-benzoquinone) (Mahmood *et al*. 1984). 3-*O*-[β-D-glucopyranosyl-(1″→2′)-β-D-glucopyranosyl], 27-*O*-β-D-glucopyranosyl-(25R)-spirost-5-ene-3β,27-diol were isolated from cell suspension cultures of *Costus speciosus*, following incubation with diosgenin (Indrayanto *et al*. 2001). Diosgenin, prosapogenin B of dioscin, diosgenone, cycloartanol, 25-en-cycloartenol and octacosanoic acid (Qiao *et al*. 2002).

Ethnopharmacy: The juice of the stem bark is taken to relieve burning sensations in urination. The filtrate of the rhizome paste is used as an ear drop to promote the healing of ear infections. A paste made from the burnt tuber, sugar and tamarind is used for the treatment of dysentery and other digestive problems (Parrotta 2001)

Conservation measures: Malabadi *et al*. (2004) achieved shoot regeneration by using thin rhizome sections. Efficient initiation of shoot buds was observed when thin rhizome sections were cultured on modified Gamborg-B5 basal medium supplemented with TDZ.

18. *Curcuma pseudomontana* Graham. - Zingiberaceae

Trade name: Hill turmeric.

Threat status: Vulnerable (Ravikumar and Ved 2000; Sumy *et al*. 2000).

Medicinal uses: It is reported to be used to treat leprosy, dysentery, cardiac diseases, haemorrhages, dysuria and general debility.

Ethnopharmacy: Savara tribes in the Eastern Ghats of Andhra Pradesh, India use rhizomes extracts to cure jaundice. Jatapu and Koya tribes apply warm rhizome paste to treat body swellings. Women of Jatapu and Savara tribes eat boiled rhizome to increase lactation. Khond tribes apply rhizome paste on the head for cooling effect. The rhizomes are boiled and eaten in times of scarcity, as a vegetable reported that rhizome are used in arrowroot manufacturing (Ravikumar and Ved 2000; Sumy *et al*. 2000; Sasikumar 2005). Food and medicinal uses recently reviewed by Voravuthikunchai (2007).

Conservation measures: Syamkumar and Sasikumar (2007) studied the molecular genetic fingerprints of *C. pseudomontana* and 15 other *Curcuma* spp. by developing Inter Simple Sequence Repeats (ISSR) and RAPD markers to elucidate the genetic diversity/relatedness among the species.

19. *Cycas circinalis* L. - Cycadaceae

Trade name: False sago, queen sago, fern palm.

Threat status: Critically endangered status and are included in the negative list of exports notified by the Government of India (Ravikumar and Ved 2000; Sumy *et al*. 2000; Reddy *et al*. 2001).

Medicinal uses: Seeds are used as an aphrodisiac as well as to improve sperm production. Bark and seeds are used as a poultice for sores and swellings. Tender leaves relieve flatulence and vomiting. Powdered endosperm is used to relieve burning sensation and general debility (Ravikumar and Ved 2000; Sumy *et al*. 2000) and neurotoxic (Kurland 1988; Perry *et al*. 1989; Allen *et al*. 1993; Gobe 1994).

Phytochemicals: β-*N*-methylamine-L-alanine (BMAA)

(Nunn *et al*. 1987; Kisby *et al*. 1988; Perry *et al*. 1989), cycasin (Matsumoto and Strong 1963), α-amino-β-methyl-aminopropionic acid (Dossaji and Bell 1973), N-(3′-one-5′-methyl)-hexylalanine, leucine betaine, N-methylisoleucine, *S*-methylcysteine, pipecolic acid, dipeptide, γ-glutamyl-leucine (Li *et al*. 1996), α-amino-β-methylaminopropionic (Vega and Bel 1967), DL-α-acetamino-β-methylaminopropionic acid (Vega *et al*. 1968).

Ethnopharmacy: Bark and seeds are ground to a fine paste with coconut oil and used as a poultice for sores and swellings. Juice of tender leaves is reported to be useful for treatment of flatulence and vomiting. Powdered endosperm of seeds is reported to be good for hyperpiesia, burning sensation and general debility (Sumy *et al*. 2000).

Conservation measures: The sex of *C. circinalis* was studied using ISSR and RAPD techniques in pre-flowering stage RAPD-derived unique male and female-specific bands of *C. circinalis* were eluted and cloned by conventional TA cloning method in pGEM-T Easy vector (Promega). Sequencing of the cloned DNA fragments was done by Sanger's dideoxy method using both forward and reverse M13 primers. Sequence homology was studied by BLAST searching. Sequencing of a male-specific RAPD band (PCR with primer OPB 01) in *C. circinalis* revealed homology with putative retro elements of diverse plants, probably indicating its use in the detection of male *C. circinalis* in the future (Gangopadhyay *et al*. 2007).

20. *Decalepis hamiltonii* W. & A. -Asclepiadaceae

Trade name: Sveta sariva.

Threat status: Globally endangered (Bais *et al*. 2000; Ravikumar and Ved 2000).

Medicinal uses: Roots are used as flavouring agent, appetizer and blood purifier while root extract is a potent antimicrobial agent, with insecticidal activity (a source of bio-insecticide) on storage food grain pests (George *et al*. 1998, 1999b) (**Figs. 13C, 14C, 14D**). Roots are reported to be used for treating indigestion, dysentery, cough, bronchitis, leucorrhoea, uterine haemorrhage, skin diseases, fever, thirst, vomiting, poisoning, polyuria, gout, wounds, chronic rheumatism, leprosy, anemia, jaundice, debility, dysuria, culinary spice, constipation and gas trouble (Sumy *et al.* 2000; Parrotta 2001). Antibacterial, antioxidant, gastroprotective, hepatoprotective, cryoprotective compounds were identified from its root extract (George *et al*. 1999; Srivastava *et al*. 2006a, 2006b; Naik *et al*. 2007; Srivastava *et al*. 2007). Through micropropgation methods root-specific flavouring compound (2-hydroxy-4-methoxy benzaldehyde) was improved (Giridhar *et al*. 2005).

Phytochemicals: The root extract and its volatile fraction containing 2-hydroxy 4-methoxybenzaldehyde (37.45%) and 2- hydroxybenzaldehyde (31.01%), as major constituents, were reported to be highly effective against several bacterial and fungal species responsible for food spoilage and other human pathologies. This suggests that the potential use of root extract as a flavourant, food preservative and anti bacterial agent (George *et al*. 1999a, 1999b; Thangadurai *et al*. 2002). The antimicrobial activity of different root extracts of *D. hamiltonii* against 15 different food related microorganisms was evaluated and among them methanolic and petroleum ether extracts were most beneficial for the bioactivity guided isolation of novel antimicrobials which prevents food spoilage (Thangadurai *et al*. 2004). The roots of *D. hamiltonii* could serve as a new source of natural antioxidants or nutraceuticals with potential applications in reducing the level of oxidative stress and related health benefits (Srivastava *et al*. 2006).

Ethnopharmacy: *D. hamiltonii* roots are highly aromatic and are used as a flavoring agent and food preservative in tribal and traditional medicine (Anitha 2001). In the Rayalaseema region of Andhra Pradesh state and parts of Karnataka state of India, the roots are used in preparing a popular cool-drink, which has a cooling effect in summer without any toxic effects on human beings (Vijayakumar and Pullaiah 1998). In India the plant and its roots are used in folk medicine as a preservative, culinary spice, flatulent reliever and in pickle preparation (Ahmedulla and Nayar 1986; Phadke *et al*. 1994). The main chemical constituent giving aromatic flavour to the roots of *D. hamiltoni* is the presence of a compound 2-hydroxy 4-methoxy benzaldehyde, which can be extracted by hydrodistillation (Giridhar *et al*. 2004). The other chemical constituents in roots that exhibit different properties are quercetin, kaempferol, lepeol, coumarin, rutin and ferulic acid (Prajapati *et al*. 2003). Unfortunately, adulteration of *Hemidesmus indicus* roots with roots of *D. hamiltonii* for flavour purpose, results in its depletion due to ruthless harvesting by the local tribes. Consequently, this has led to the acute scarcity of the plant in its natural habitats and has earned this taxon a place in the endangered list of plant species in the IUCN category (www.iucn.org).

Conservation measures: Rapid *in vitro* propagation of *D. hamiltonii* was successfully established using nodal explants of seedlings with the highest number of shoots (10-14) produced on MS medium supplemented with 3.0 mg L^{-1} BAP + 0.5 mg L^{-1} KN + 0.5 mg L^{-1} NAA with coconut milk (10%) along with ascorbic acid (150 mg L^{-1}) and 60% field survival was recoded (Anitha and Pullaiah 2002). Axillary buds obtained from field grown plants of *D. hamiltonii* were used to initiate multiple shoots on MS medium supplemented with 1.5 mg L^{-1} BAP and 0.5 mg L^{-1} IAA (Giridhar *et al*. 2004). The combination of BAP (1.1 μM) + GA_3 (5.8 μM) + phloroglucinol (800 μM) was found to be effective for nodal explants, which initiated a maximum of 4-5 multiple shoots with least callusing from base of the explant within 4-6 weeks (Gururaj *et al*. 2004). Addition of 40 μM silver nitrate on ethephon comprising MS rooting medium with IAA (0.5 mg L^{-1}) results in improved *in vitro* root initiation and elongation (Bais *et al*. 2000). When *in vitro* derived shoots were dipped in IBA (4.4 μM) solution for 30 minutes and inoculated on MS medium with 0.25% AC, 100% rooting was achieved with a maximum field survival rate of 90% (Reddy *et al*. 2001). Due to its severe threatened category in the wild and in order to strengthen the existing germplasm, genetic diversity analysis among the eight accessions of *D. hamiltonii* using RAPD markers with high (89.5%) polymorphism were reported by Raju (2006).

21. *Drosera burmanii* Vahl. and *D. indica* L. - Droseraceae

Trade name: Droserae Herba or Hebae Drosera.

Threat status: Vulnerable (Ravikumar and Ved 2000; Reddy *et al*. 2001).

Medicinal uses: The crushed leaves of *D. burmanii* **(Figs. 11, 12)** have been described as vesicant and acrid. It is considered to be a powerful rubefacient in Hindu medicine (http://BoDD.cf.ac.uk/BotDermFolder/BotDermD/DROS.html). Plumbagin and other phytochemicals act as immunomodulator, antispasmodic, anticancer, antimicrobial, antiviral, anti-inflammatory, antioxidants and are used for curing various infectious diseases. They are also shown to enhance *in vitro* phagocytosis of human granulocytes (Havsteen 1983; Finnie and van Staden 1993; Sugihara *et al*. 1999; Ravikumar and Ved 2000; Jayaram and Prasad 2006a). The whole plant on maceration is reported to be used as an external application on corns (Ravikumar and Ved 2000).

Phytochemicals: Plumbagin (2-methyl-5-hydroxy-1,4-

Fig. 11 Location for *in situ* conservation of *Drosera indica* in the field gene bank of University of Hyderabad. (**A**) Natural habitat of *Drosera* sp. threatened due to urbanization. (**B-E**) Natural hotspots of *Drosera* on the University of Hyderabad campus. (**F**) Dense growth of *D. indica* on rocky outcrop (natural habitat in University of Hyderabad campus). (**G**) Insects trapped by leaf tentacles of *D. indica*.

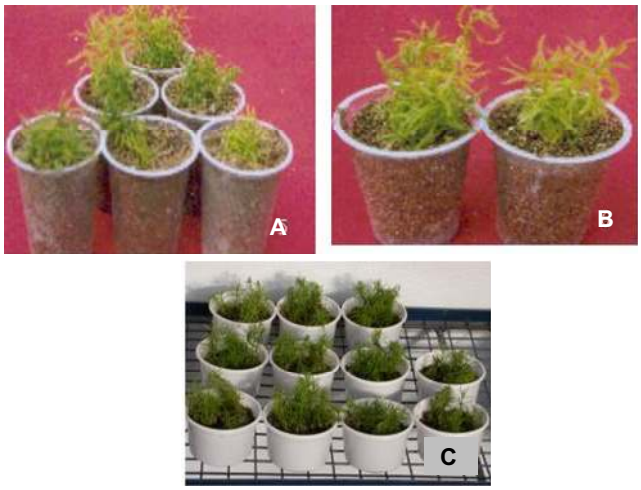

Fig. 12A-C Rapid *in vitro* multiplication of *Drosera indica*.

naphthoquinone), 7-methyljuglone (5-hydroxy-7-methyl,4-naphthoquinone) (Zenk *et al*. 1969), quercetin and hyperoside (Wang *et al*. 1998).

Conservation measures: In order to conserve, Jayaram and Prasad (2006b) initially attempted to multiply plants by germinating seeds in both *in vivo* and *in vitro* conditions by various treatments. However, in both the species the percentage of germination was negligible. In order to standardize a reliable *in vitro* multiplication protocol, shoot tips of *D. indica* and *D. burmanii* were tested with different strengths of MS medium (1/4, 1/3, 1/2, full strength), different percentages of sucrose (1, 2, 3%), various pH (3.7, 4.7, 5.7, 6.7) and for *D. indica*, MS basal medium fortified with different concentrations of zeatin, KN (0.1, 0.5, 1.0, 2.0 mg L^{-1}) and BAP (0.01, 0.05, 0.1 mg L^{-1}) were tested. For *D. burmanii*, MS medium fortified with lower concentrations of kinetin and BAP (0.01, 0.05 and 0.1 mg L^{-1}) individually were tried. Profuse multiple shoot production was observed in both species i.e., large-scale production of biomass can be obtained which can be further used for plumbagin production apart from long term *in vitro* germplasm storage for conservation and management purposes (Jayaram and Prasad 2005, 2007, 2008, in press). Nalini and Murali (2002) also established the *in vitro* regeneration protocol from the callus of nodal segments of *D. indica*.

22. *Embelia ribes* Burm.f. - Myrsinaceae

Trade name: Vidanga, Baberang, Bashmak or Krimigna, Embelia.

Threat status: Threatened (Ravikumar and Ved 2000; Sumy *et al*. 2000; Reddy *et al*. 2001).

Medicinal uses: Swamy *et al*. (2007) reviewed the literature on this plant and reported that it is used as an adjuvant in most drug preparations. It is also used in the treatment of anti-inflammation to relive rheumatism and fever. The fruit is bitter in taste but is a good appetizer. It cures tumors, ascites, bronchitis, jaundice and mental disorders. The seeds are used as an antibiotic, anthelmintic, antituberculosis, alterative and stimulative. Leaves are astringent, demulcent, depurative and useful in pruritus, sore throat, ulcers of mouth, indolecent, skin diseases and leprosy. Traditional medical practitioners residing in the vicinity of the Lakkinakoppa forest range of Bhadra Wild life Sanctuary, India use the tender leaf paste of this species to cure cut wounds and leprosy. Fruits contain a quinone derivative embelin (3-undecyl 2,5-dihydroxy, 1,4-benzoquinone), an alkaloid christembine and a volatile oil vilangin; its chemical constituent is 2,5-dihydroxy-4-undecyl-3,6-benzoquinone. The biological activities of this species have been evaluated for their anti-spermatogenic effect and treatment of urinary tract infections. Only the fruits of this species have been subjected to rigorous phytochemical and pharmacological studies (see the references cited in Swamy *et al*. (2007). Root infusion given for coughs and diarrhoea, decoction of dried fruits is used for fevers and diseases of chest and skin. Dried fruit is anthelmintic (Hördegen *et al*. 2006), astringent tonic used in scorpion-sting and snake-bite. Leaves are useful in pruritis, skin diseases, leprosy (Sumy *et al*. 2000), light acrid, alternative, nervine tonic, used to relieve constipation, colic, indigestion, flatulence, piles, leprosy and skin diseases. The paste is locally applied against ringworm and other skin infection. Seed powder is used to cure headache. Roots improve digestion and cure flatulence plus colic. Powder made from dried bark of the root is a reputed remedy for toothache (Ravikumar and Ved 2000), retinotoxicity (Low *et al*. 1985), molluscicides (Rao and Singh 2001), antibacterial (Chitra *et al*. 2003), chemopreventive effects against DENA/PB-induced hepatocarcinogenesis (Sreepriya and Bali 2005), wound healing activity (Swamy *et al*. 2007), analgesic (Atal *et al*. 1984), insecticidal activity (Chander and Ahmed 1989), contraceptive (Chaudhury *et al*. 2001), improvement of cognition (Vinutha *et al*. 2007).

Phytochemicals: Embelin (Chander and Ahmed 1987; Chitra *et al*. 2003), vilangin, anhydrovilangin, quinone diimines, *N*-bis-anhydrobenzoquinones, *N*-bis(anhydro-2,5-dihydroxy-3,6-benquinones) (Rao and Venkateswarlu 1962, 1964a, 1964b, 1964c, 1965), ethylene-bis(2,5-dihydroxy-4-tridecyl-3,6-benzoquinones) or their anhydro derivatives; *N*-bis(anhydro-5-hydroxy-4-tridecyl-3,6-benzoquinones) (Murty *et al*. 1967).

Ethnopharmacy: The root infusion is given for coughs and diarrhoea. Decoction of dried fruits is used to treat fever and diseases of chest and skin. Dried fruit is used as a tonic to treat scorpion sting and snake bite. Leaf paste is used to treat pruiritis, skin diseases and leprosy (Sumy *et al*. 2000).

Conservation measures: Raghu *et al*. (2006) developed direct plant regeneration from *in vitro* derived leaf explants. The developed *in vitro* protocol involved three steps that included induction of shoot initials from leaf tissue, regeneration and elongation of shoots and rooting of shoots. The best medium for shoot induction was MS with 0.272 mM TDZ. The shoots rooted on half-strength MS basal medium supplemented with 4.90 mM IBA and 3% (w/v) sucrose. The rooted plants could be established in soil with 70% success.

23. *Entada pursaetha* DC - Mimosoideae

Trade name: None.

Threat status: Endangered (Reddy *et al*. 2001).

Medicinal uses: The seeds, made into a paste, applied locally to relieve inflammatory and glandular swellings. Paste used as a fish poison and is considered as tonic, emetic, antiperiodic, and anthelmintic. The juice extracted from the bark and wood is applied externally to relieve ulcers (Parrotta 2001).

Phytochemicals: L-tyrosine *O*-glucoside, dopamine-3-*O*-glucoside (Larsen *et al*. 1973), pursaethosides-A, B, C, D, E and phaseoloidin (Tapondjou *et al*. 2005).

Ethnopharmacy: The seeds are used as a fish poison and the paste is applied locally to relieve inflammatory and glandular swellings. The bark and the wood juice are applied externally to relieve ulcers (Parrotta 2001).

Conservation measures: Vidya *et al*. (2005) successfully established a micropropagation protocol by using cotyledonary nodal explants. MS medium fortified with BAP (5 mg L^{-1}) + NAA (0.5 mg L^{-1}) induced adventitious shoots. It was observed that, the frequency of shoot production was 98.7% in the proximal transverse half of the cotyledon. The shoots were transferred to half-strength MS medium supplemented with 2 mg L^{-1} IBA for root induction. The survival rate was ~70%.

24. *Fagonia cretica* Linn. - Zygophyllaceae

Trade name: None.

Threat status: Vulnerable (Reddy *et al.* 2001).

Medicinal uses: Antioxidant (Rawal *et al*. 2004a, 2004b), antibacterial (Gehlot and Bohra 2000), analgesic, antipyretic and anti-inflammatory (El-Shabrawy *et al*. 1997), antimicrobial (Thetwar *et al*. 2006). It is a reputed medicinal plant in folkloric medicine. An aqueous decoction of the aerial parts of the plant is a popular remedy in the indigenous system of medicine for cancer and for the treatment of various other diseases of digestive and blood vascular system. Saeed and Sabir (2003) reported two major triterpenoid saponin glycosides from its aerial parts and investigated their effects on four of the blood parameters in male rabbits such as red blood cells (RBC) count, haemoglobin concentration (HC), mean corpuscularhaemoglobin (MCH) and on total leukocyte count (WBC) under laboratory conditions.

Phytochemicals: Saponin-I and saponin-II (Saeed and Sabir 2003). 3-*O*-[β-D-glucopyranosyl (1→2)-α-L-arabinopyranosyl] hederagenin 28-*O*-β-D-glucopyranosyl ester, 3-*O*-[β-D-glucopyranosyl (1→2)-α-L-arabinopyranosyl] oleanolic acid 28-*O*-[β-D-glucopyranosyl (1→6)-β-D-glucopyranosyl] ester, 3-*O*-[β-D-glucopyranosyl (1→2)-α-L-arabinopyrangsyl] 27-hydroxy oleanolic acid 28-*O*-[β-D-glucopyranosyl (1→6)-β-D-glucopyranosyl] ester, 3β-*O*-[β-D-glucopyranosyl (1→2)-α-L-arabinopyranosyl] olean-12-en-27-al-28-oic acid 28-*O*-[β-D-glucopyranosyl (1→6)-β-D-glucopyranosyl] ester (Khalik *et al*. 2000). 3-*O*-[β-D-xylopyranosyl(1→2)α-L-arabinopyranosyl] 27-hydroxyoleanolic acid, 28-O-[β-D-glucopyranosyl(1→6)[β-D-glucopyranosyl]ester, 3β-*O*-[β-D-xylopyranosyl(1→2) α-L-arabinopyranosyl] olean-12-en-27-al-28-oic acid (Abdel-Khalik *et al*. 2001), hederagenin-3-*O*-α-L-arabinopyranosyl-28-*O*-β-D-glucopyranoside, hederagenin-3-*O*-β-D-xylopyranosyl (1→2)-α-L-arabinopyranosyl-28-*O*-β-D-glucopyranoside and oleanolic acid 3-*O*-β-D-glucopyranosyl (1→2)-α-L-arabinopyranosyl-28-*O*-β-D-glucopyranoside (Melek *et al*. 1994).

25. *Gardenia gummifera* L. f. - Rubiaceae

Trade name: Dikamali gum.

Threat status: Vulnerable (Ravikumar and Ved 2000; Sumy *et al*. 2000; Reddy *et al*. 2001).

Medicinal uses: Resin from leaf buds are used in curing wounds, indigestion, gas trouble, piles, chronic coughs, neuropathy, anorexia, colic, foul ulcers, intestinal round worms, cardiac debility, leprosy, skin diseases, intermittent fever, enlargement of the spleen, obesity, antispasmodic, antiseptic, antihelmintic and reportedly useful in cases of splenomegaly, odontalgia, wounds and also used in veterinary medicine to keep off flies from sores (Ravikumar and Ved 2000; Sumy *et al*. 2000), larvicidal activity against *Culex quinquefasciatus* (Suryadevara and Khanam 2002), anticonvulsant activity (Achliy *et al*. 2004), analgesic, anti-inflammatory, antipyretic (Sridhar *et al*. 2003).

Phytochemicals: Gardenin-A (Mathuram *et al*. 1998; Chauhan *et al*. 2001; Sadishkumar *et al*. 2003; Gunasekaran *et al*. 2005), 5,7,3′,4′-tetrahydroxy-6,8-dimethoxyflavone, wogonin derivative, 5,7,3′,5′-tetrahydroxy-8,4′-dimethoxyflavone (Chhabra *et al*. 1977), flavonoids and free phenolic compounds (Sridhar *et al*. 2003).

Ethnopharmacy: The gum is used to treat children to treat nervous disorders and diarrhoea due to teething and is applied to the gums to relieve irritation. Among the tribals the gum is crushed in water to treat worms, vomiting and hysteria. The gum is also used to treat foul ulcers, wounds and obesity (Sumy *et al*. 2000; Parrotta 2001). Sedative and anticonvulsant activities of Unmadnashak Ghrita (UG) were evaluated by Achliya *et al*. (2004). UG 'Unmad' is a condition described in ayurvedic science which pertains to a CNS disorder and resembles schizophrenia, mania and excitement. The word 'Nashak' means 'anti', thus "unmadnashak" means formulation which antagonizes CNS excitement symptoms. It is a "pachagavy" (pancha = five [milk, ghee (clarified butter fat), curd, urine and dung]; gavya = products obtained from cow). There are a large number of formulations mentioned in ancient ayurvedic literature containing panchagavya components that are administered either alone, or in combination with other herbal mineral or animal origin for the treatment of several diseases. Ghritas are one of the subclass of panchagavya ayurvedic formulations in which cow's ghee is boiled with prescribed 'Kasayas' (decoction of herbal ingredient) and 'Kalkas' (aqueous paste of powdered herbal drugs) according to the ayuvedic

literature. The components of UG are *Ferula narthex* (6 g), *Gardenia gummifera* (6 g), *Ellataria cardamom* (6 g), *Bacopa monneri* (6 g) and cow's ghee (76 g). UG is indicated in Ayurveda for the treatment of mania, epilepsy and other disorders of central nervous system (please refer to Achliya *et al*. 2004 and the references threin).

26. *Gloriosa superba* L. - Colchicaceae

Trade name: Malabar glory lily.

Threat status: Vulnerable (Ravikumar and Ved 2000; Sumy *et al*. 2000; Reddy *et al*. 2001).

Medicinal uses: Tubers and seeds are rich source of colchicine and are reported to have abortifacient, antipyretic, anti-inflammatory and antileprotic properties, and are used to treat parasitical affections of skin, piles, gout, chronic ulcers, piles, carcinoma, diarrhoea, skin disorders, gonorrhoea, lice eradication, rheumatism, promoting labour pain and expulsion of placenta (Sumy *et al*. 2000). The seeds are used as precursor raw material for the manufacture of drugs for gout (Rao *et al*. 1999; Sumy *et al*. 2000). In Ayurveda the tuber is considered anthelmintic, laxative and alexiteric; it is used to treat chronic ulcers, leprosy, inflammation, piles, abdominal pains, itching and thirst. The powdered tuber is reportedly used in the form of a paste as a local application for parasitic skin diseases, as a cataplasm for relieving rheumatic pains, and as an external application to promote the expulsion of the placenta after childbirth (Parrotta 2001). The white, starchy powder obtained after repeated grinding and washing of the tubers is reportedly taken to treat gonorrhoea and as an abortifacient (Parrotta 2001). The tuberous roots are useful in curing inflammations, ulcers, scrofula, bleeding piles, white discharge, skin diseases, leprosy, indigestion, helminthiasis, snake bites, baldness, intermittent fever and debility. Roots are given internally as an antidote for snake poison. It causes vomiting, purging, stomachache and burning sensation (Ravikumar and Ved 2000), neurotoxic (Carod-Artal 2003), gastroenteritis, acute renal failure, cardiotoxicity, haematological abnormalities (Mendis 1989), sweating, hypotension, jaundice, bradycardia and convulsions (Aleem 1992).

Phytochemicals: colchicine (Poulev *et al*. 1994; Chauhan *et al*. 1998; Bharathi *et al*. 2006); colchicine glycoside, 3-*O*-demethylcolchicine-3-*O*-α-D-glucopyranoside (Suri *et al*. 2001); 1,2-didemethylcolchicine, 2,3-didemethylcolchicine, 3-demethylcolchicine, *N*-formyl-*N*-deacetylcolchicine, and colchicoside (Chaudhuri and Thakur 1993).

Ethnopharmacy: The tuber paste is applied locally on the skin to treat parasitic diseases as a cataplasm for relieving rheumatic pains and as an external application to promote the expulsion of the placenta after childbirth. The white starchy powder obtained after repeated grinding and washing of the tubers is taken to treat gonorrhoea as an abortifacient (Parrotta 2001).

Conservation measures: Ghosh *et al*. (2007) developed a protocol for *in vitro* tuber production using non-dormant tubers on MS medium without plant growth regulators. Sivakumar and Krishnamurthy (2004) developed an efficient protocol for regeneration of plants derived from young leaves, stems, pedicels, shoot tips, roots and corm buds from both *in vivo* and *in vitro* raised plants. MS medium supplemented with various concentrations and combinations of auxin, cytokinin and organic acids was used. 98% of callus induction occurred in nondormant corm bud explants. The greatest number of multiple shoots was observed in corm-derived calluses. Vigorous root formation occurred in all cases when multiple shoots were derived. Histomorphogenetic studies revealed that not only the origin of shoot and root buds in *in vitro* systems, but the morphology and structure of leaves resemble those of *in vivo* plants too. Ghosh *et al*. (2002, 2006) were treated with 5 mM methyl jasmonate, $AlCl_3$ to the root cultures of *G. superba*, which enhanced the intracellular colchicine content. Sivakumar *et al*. (2004) standardized the enhanced *in vitro* production of colchicine production by supplying exogenous precursors for the biosynthesis of colchicine using B_5 medium. Sivakumar *et al*. (2003a) established the *in vitro* production of corms by using three kinds of explants: dormant, non-dormant corm buds and 30 days-old *in vitro*-derived shoots. Excellent responses was obtained in terms of corm production using MS medium supplemented with B_5 vitamins, 6% sucrose, 2-iP, Adenine sulphate (ADS) and Ancymidol (ANL) for corm formation from dormant corm buds, using Kin, ADS and ANL for corm formation from non-dormant corm buds and using BAP, ADS and ANL for callus derived multiple shoot corm formation. Well developed corms were obtained from the tissue cultured plants with no dormancy breaking requirement. Sivakumar *et al*. (2003b) established the induction, maturation and germination of embryoids from leaf tissue. Nodular calli were obtained from Schenk and Hildebrandt (SH) medium supplemented with 2,4-D and 2-iP. In solid culture, the nodular calli when transferred to 2,4-D along with glycerol gave the best response (68.4%) in embryoid induction after 20 days. After two subcultures at 7-day intervals in a medium with thiamine instead of glycerol, the embryoids matured. When mature embryoids were transferred to BAP and IBA medium, they gave rise to plantlets with single shoots and roots. In liquid culture, the medium supplemented with NAA and L-glutamine with continuous agitation, the embryoidogenic calli produced embryoids (85%) after 21 days. The mature embryoids began to turn green and produced shoots and elongated "radicles" after 35 days.

27. *Gymnema sylvestre* (Retz.) R. Br. ex Schu. - Asclepiadaceae

Trade names: Periploca of the woods; Sugar killer.

Threat status: Nearly threatened (Srinivasamurthy and Ghate 2002).

Medicinal importance: The plant is considered to be antidiabetic, antiperiodic, diuretic, anthelmintic, antibronchitic and stomachic. The root and leaf extracts are used to treat headache, hydrocele, polyuria, leprosy, wounds and bronchial asthma. The leaves are antidiabetic, used to treat parageusia, furunculosis, errhine, malaria and cold. The root is considered to possess astringent, emetic, expectorant, cooling, stomachic, larvicidal and tonic properties (Sumy *et al*. 2000; Parrotta 2001; Joshi *et al*. 2007; Khanna and Kannabiran 2007). It also exhibits anti-inflammatory (Ray *et al*. 2006) and antioxidant properties (Ohmori *et al*. 2005).

Ethnopharmacy: Among tribal women, leaves mixed with a small portion of the seed kernel of *Syzygium cumini* (Myrtaceae), are reportedly taken with water on an empty stomach to regularize the menstrual cycle. The leaf paste is used externally to promote the healing of bone fractures. The Gonds of Andhra Pradesh, the filtered extract of the ground leaf twigs is taken orally to relieve malarial fever (Chhetri *et al*. 2005). The response achieved due to various phytochemicals isolated from different parts is shown in **Table 16**.

Phytochemicals: Khanna and Kannabiran (2007) reported the presense of alkaloids, saponins, carbohydrates, phytosterols, phenols, flavonoids, terpenoids, tannins and phlebatannins in aqueous root extracts. Two new flavonol glycosides, namely kaempferol 3-*O*-β-D-glucopyranosyl-(1→4)-α-L-rhamnopyranosyl-(1→6)-β-D-galactopyranoside and quercetin 3-*O*-600-(3-hydroxyl-3-methyl-glutaryl)-β-D-glucopyranoside were isolated from *G. sylvestre by* Liu *et al*. (2004). Mukhopadhayaya and Field (2006) characterized kaempferol 3-*O*-β-D-glucopyranosyl-(1→4)-α-L-rhamnopy-

Table 16 Response of various chemical constituents isolated from different parts of *G. sylvestre*.

Part used	Response	Reference
Roots: Diabecon	Cataracts, diabetes.	Moghaddam *et al*. 2004
Placebo of the plant: Hydroxycitric acid + niacin-bound chromium	Weight management in humans.	Preuss *et al*. 2004
Ethanolic extract of whole plant	Antimicrobial.	Satdive *et al*. 2003
Roots, triterpenes, oleanane saponins	-	Ye *et al*. 2000
Whole plant	Antiperiodic, diuretic, stomachic.	Parrotta 2001
Roots + leaves	Headache, hydrocele, polyuria, leprosy, pruritis, poisoning, wounds, bronchial asthma.	Parrotta 2001
Leaves	Hypoglycaemic, diabetis, cough, fever.	Parrotta 2001
Seeds	Emetic, cold.	Parrotta 2001
Root	Astringent, emetic, expectorant, cooling, stomachachic.	Parrotta 2001
Leaf powder	Heart and circulatory system and urine production, parageusia, furunculosis and errhine.	Parrotta 2001
Leaf paste	Bone fractures.	Parrotta 2001
Leaf paste + castor oil	Swollen glands and enlarged spleen.	Parrotta 2001

Table 17 *In vitro* multiplication of *G. sylvestre*.

Explant	Medium composition	VP/MSM	Reference
Nodal segments	Embryogenic callus induction was observed in 0.5 mg L^{-1} of 2,4-D in MS medium.	MSM	Gopi and Vatsala 2006
Stem cuttings	No hormones.	VP	Rao *et al*. 2000
Axillary nodes	MS + BAP (1 mg L^{-1}), KN (0.5 mg L^{-1}), NAA (0.1 mg L^{-1}), malt extract (100 mg L^{-1}) and citric acid (100 mg L^{-1}).	MSM	Komalavalli and Rao 2000
Nodal segments	MS media containing different combinations of BAP or KN with NAA.	MSM	Reddy *et al*. 1998

Abbreviations: 2,4-D: 2,4-dichlorophenoxy acetic acid; BAP: 6-benzylaminopurine; KN: kinetin; MSM: Murashige and Skoog (1962) medium; NAA: α-naphthaleneacetic acid. VP: Vegetative propagation

ranosyl-(1→6)-β-D-galactopyranoside from its roots.

Conservation measures: *In vitro* clonal multiplications were carried out using different explants by various groups (**Table 17**). Work carried out in our laboratory: Both inter- and intrapopulation diversity analysis was carried out by using RAPD markers for the germplasm collected from various locations of Andhra Pradesh.

28. *Ocimum sanctum* L. - Lamiaceae

Trade name: Holy basil; Tulsi.

Threat status: Common.

Medicinal uses: *O. sanctum* has been mentioned in Indian system of traditional medicine. It is used to treat hypoglycemia, hyperglycemia (Grover *et al*. 2002; Kar *et al*. 2003; Vats *et al*. 2004). It also exhibits antioxidant (Juntachote and Berghofer 2005), antiproliferative (Rastogi *et al*. 2007), anthelmintic (Asha *et al*. 2001), anticarcinogenic (Aruna and Sivaramakrishnan 1992), antidermatitic (Lertsatitthanakorn *et al*. 2006), anti-ulcerogenic (Dharmani *et al*. 2004), anti-inflammatory (Singh *et al*. 1996; Singh and Majumdar 1999), anticataract (Halder *et al*. 2003), and antipyretic (Godhwani *et al*. 1987) activities, blood sugar lowering (Chattopadhyay 1999a), analgesic (Khanna and Bhatia 2003), chemopreventive (Karthikeyan *et al*. 1999; Prakash and Gupta 2000), hypotensive (Singh *et al*. 2001), immunomodulatory (Mediratta *et al*. 2002), immunoregulatory (Godhwani *et al*. 1988). It also has significant ability to scavenge highly reactive free radicals, and posesses anti-lipidperoxidative activity (Geetha *et al*. 2004), antioxidant (Panda and Kar 1998; Samson *et al*. 2007), anti-thyroidic and antiatherogenic effect (Mary *et al*. 2003) activities.

Phytochemicals: Eugenol (Asha *et al*. 2001), apigenin, β-carotene, citric acid, fatty acids, fumaric acid, linalool, luteolin, malic acid, oxalic acid, phenols, sterols, succinic acid (Farnsworth and Bunyapraphatsara 1992), (*Z*)-3-hexenol, ethyl 2-methyl butyrate, α-pinene, β-pinene, myrcene, limonene, (*E*)-β-ocimene, γ-terpinene, *trans*-linalool oxide, linalool, eugenol, methyl eugenol, β-elemene, (*E*)-cinnamyl acetate, β-caryophyllene, isoeugenol, α-guaiene, α-humulene, β-selinene, α-muurolene, δ-cadinene, nerolidol, caryophyllene oxide, α-guaiol, τ-cadinol, β-eudesmol, α-bisabolol, (*E*,*Z*)-farnesol (Kothari *et al*. 2004), orientin and vicenin (Vrinda and Devi 2001).

Ethnopharmacy: The tribals in Southern West Bengal use the paste of leaves mixed with roots of *Calotropis procera* to treat menorrhagia. A decoction of the root is given as a diaphoretic in the treatment of malarial fevers (Parrotta 2001). In India since it is considered as sacred plant, used in various rituals.

Conservation measures: When shoot tip and leaf explants were cultured on different concentrations and combinations of growth regulators, the highest percentage of shoot formation and highest average number of shoots were observed 90% and 5.88, in 0.2 mg L^{-1} BAP from shoot tip explants. Callus induction was obtained within 12-15 days of culture from leaf explants. The highest frequency (90%) of organic callus induction was observed on MS medium containing 1.0 mg L^{-1} NAA. The highest percentage of shoot regeneration was obtained 90% in 0.2 mg L^{-1} BAP. *In vitro* grown shoots rooted best on MS medium containing 0.1 mg L^{-1} NAA (Banu and Miah 2007). Maximum number of multiple shoots was obtained on MS medium supplemented with BAP (1.0 mg L^{-1}) and KN (2.0 mg L^{-1}) combination from both shoot tip and nodal explants. About 75% of the *in vitro* regenerated shoots were rooted on MS liquid medium containing NAA (1.0 mg L^{-1}) within 2-3 weeks of culture (Girija *et al.* 2006). Of the various levels of BAP tested, MS + BAP (1.0 mg L^{-1}) produced the maximum number of shoots from inflorescence explants. Incorporation of IAA (0.05 mg L^{-1}) along with BAP (1.0 mg L^{-1}) in the culture medium showed a marked increase in the number of shoots. About 92% of the *in vitro* regenerated shoots rooted on MS hormone-free medium within 2-3 weeks (Singh and Sehgal 1999). The regenerated plantlets could be successfully established in soil, where they grew normally.

29. *Oroxylum indicum* Vent. - Bignoniaceae

Trade name: Shyonaaka mool chaal, Sonaapaathaa mool chaal, Indian trumpet tree.

Threat status: Vulnerable (Ravikumar and Ved 2000; Sumy *et al*. 2000; Reddy *et al*. 2001; Dalal and Rai 2004).

Medicinal uses: All parts of the plant are used for medicinal purposes. This plant is an important herbal medicine in many Asian countries and is used in folk medicine as a cure for various diseases (Biswas and Ghosh 1994). Different plant parts are considered to be hot, bitter, astringent, used for curing fevers, diarrhoea, dysentery, abdominal pain, rheumatism, thirst, vomiting, anorexia, worms, leprosy, treat dropsy and eruptive fevers sprains, hiccough, cough, asthma, bronchitis, gout, leucoderma, carminative, diuretic, stomachic, aphrodisiac, anti-inflammatory, appetizer (Bhattacharje and Das 1969; Manonmani *et al*. 1995; Kirtikar and Basu 1996; Ravikumar and Ved 2000; Sumy *et al*. 2000; Parrotta 2001; Dalal and Rai 2004), various phytochemicals showed anti-cancer (Mao 2002), antimutagenic (Wall *et al*. 1988), antibacterial activities (Nakahara *et al*. 2001; Jiwajinda *et al*. 2002; Nakahara *et al*. 2002), antimicrobial activity (Rasadah *et al*. 1998), antiproliferative (Lambertini *et al*. 2004), antifungal (Ali *et al*. 1998), snakebite, diarrohea and dysentry (Bhattacharya 1980; Ghani 1998), cytotoxic (Uddin *et al*. 2003). According to the reviewed literature by Costa-Lotufo *et al*. (2005), it is reported to be an antiproliferative, anti-breast cancer, an estrogen receptor inhibitor, antioxidant, anti-arthritic and antimutagenic.

Phytochemicals: Anthraquinone, aloe-emodin (Dey *et al*. 1978), oroxylin A, chrysin, triterpene carboxylic acid, urosolic acid (Jiwajinda *et al*. 2002), baicalein (Nakahara *et al*. 2002), chrysin, oroxylin A, baicalein glycosides, benzoic acid, fatty acids (Nakahara *et al*. 2001; Chen *et al*. 2003), terpenes, alkaloids, and saponins (Bhattacharje and Das 1969), oroxylin A, chrysin, scutellarin-7-rutinoside, traces of alkaloids (Subramanian and Nair 1972), tannic acid, sitosterol, galactose (Dalal and Rai 2004), lapachol, β-lapachone (Ali *et al*. 1998), 2,5-dihydroxy-6,7-dimethoxyflavone, 3,7,3′,5′-tetramethoxy-4-hydroxy flavones (Uddin *et al*. 2003).

Ethnopharmacy: The root bark boiled on sesame oil is used to cure otorrhoea. The decoction is used to treat dropsy and eruptive fevers. The powdered stem bark is used to treat fever and leprosy among tribal children. The powdered seeds mixed with mustard oil are used to reduce joint pain. The leaves are used externally for relieving enlarged spleen, headache and ulcers. Among the tribal inhabitants the crushed leaves are applied to relieve joint pains. A decoction of the leaves is used to relieve stomachache and rheumatism. The young shoots and unripe fruits are eaten as vegetables (Parrotta 2001).

Conservation measures: Dalal and Rai (2004) successfully established an *in vitro* protocol using cotyledonary nodal explants. MS medium supplemented with BAP (8.87 μM) and IAA (2.85 μM) was suitable for induction of multiple shoots. It was observed that repeated subculturing of cotyledonary node and *in vitro* developed nodal segments in MS medium with BAP (4.44 μM) at 4-week intervals resulted in continuous mass multiplication of shoots. Profuse rooting was observed (91.6%) when MS strength was reduced to one-quarter and combined with NAA (2.69 μM) and IAA (5.71 μM) with a survival rate of 70%. Jayaram (2005) conducted genetic diversity analysis by using RAPD.

30. *Piper longum* L. - Piperaceae

Trade name: Pipplamool, bara papal, chota papal, long pepper.

Threat status: Vulnerable (Ravikumar and Ved 2000; Sumy *et al*. 2000; Reddy *et al*. 2001).

Medicinal uses: In Ayurveda, a mixture of the dried fruits of *P. nigrum* and the dried rhizomes of *Zingiber officinale* in a 1:1:1 proportion is known as "Trikatu". Out of the 370 formulations listed in the Handbook of Domestic Medicine and Common Ayurvedic Remedies, 210 contain either Trikatu or its individual components. Trikatu has gained importance in the traditional complimentary system of medicine due to its chief alkaloidal constituent, viz. piperine (Lala *et al*. 2004). The literature has revealed a number of pharmacological properties of piperine, such as anticancer (Sunila and Kuttan 2004; Selvendiran *et al*. 2005a, 2005b; Selvendiran *et al*. 2006), adulticidal activity against mosquito vectors (Chaiyasit *et al*. 2006), stomach disease (Wu *et al*. 2004), contraceptive (Joshi *et al*. 1977; Prakash 1984; Chaudhury *et al*. 2001; Balasinor *et al*. 2007), larvicidal activity (Lee 2000; Yang *et al*. 2002; Chaithong *et al*. 2006), anti-allergic (Amit *et al*. 2003), anti-pyretic, anti-depressant (Lee *et al*. 2005), hepatoprotective and antitumor, immunomodulatory, anti-apoptotic (Pathak and Khandelwal 2006), antimetastatic activity (Pradeep and Kuttan 2002), fungicidal activity (Lee *et al*. 2001), insecticidal and acaricidal activity (Latha *et al*. 1999; Park *et al*. 2002), anthelmintic (Raje *et al*. 2004), pulmonary tuberculosis (Hu *et al*. 2005), antioxidant (Karthikeyan and Rani 2003; D'Souza *et al*. 2004; Natarajan *et al*. 2006; Selvendiran *et al*. 2006), antiepileptic (Velpandian *et al*. 2001), thermogenic, antiobesity (Kaur and Kulkarni 2001), cytotoxic activity (Padmaja *et al*. 2002), radioprotective property (Sunila and Kuttan 2005), rejuvenating activity (Suthar *et al*. 2003), rheumatism, insomnia, palsy and epilepsy, analgesic activity (Vedhanayaki *et al*. 2003), antiulcer (Agrawal *et al*. 2000), immunomodulatory (Sunila and Kuttan 2004), antiangiogenic activity (Sunila and Kuttan 2006), intestinal distress (Ghoshal *et al*. 1996), anti-amoebic (Ghoshal *et al*. 1996; Ghoshal and Lakshmi 2002; Sawangjaroen *et al*. 2004), antiviral activity (Prasad *et al*. 2005), adaptogenic potential (Rege *et al*. 1999), antifibrotic (Christina *et al*. 2006), embryotoxicity and teratogenicity (Chaudhury *et al*. 2001), chronic dysentery and anti-giardial and immuno-stimulatory (Agarwal *et al*. 1994, 1997; Tripathi *et al*. 1999), increase in serum gonadotropins and a decrease in intratesticular testosterone concentration (Malini *et al*. 1999), bioavailability-enhancing activity (Atal *et al*. 1981; Khajuria *et al*. 2002; Lala *et al*. 2004; Pattanaik *et al*. 2006), antihistaminic, antispasmodic, mast-cell stabilization activities (Amit *et al*. 2003, 2005), mosquitocide (Choochote *et al*. 2006), antifertility effect (Munshi *et al*. 1977), antihepatotoxic potential (Koul and Kapil 1993), spermatotoxic effect (Shah *et al*. 1998), antibacterial activity (Srinivasa Reddy *et al*. 2001; Srinivas *et al*. 2004), antifertility effect (Lakshmi *et al*. 2006), antiaflatoxigenic (Lee *et al*. 2002), analgesic (Park *et al*. 2001), anti-diabetic (Purohit and Daradka 1999), anti-diarrheic (Sawangjaroen and Sawangharoen 2005), and anti-inflammatory (Pratibha *et al*. 2004).

Roots and fruitings spikes are used in treating diarrhoea, indigestion, jaundice, urticaria, abdominal disorders, hoarseness of voice, asthma, hiccough, cough, piles, malarial fever, flatulence, vomiting, thirst, oedema, earache, wheezing, chest conjestion, throat infections, worms and sinusitis. This is one of the ingredients in the Siddha medicine "trikadugu". Also considered a rejuvenating plant (Ravikumar and Ved 2000; Sumy *et al*. 2000) Bronchial asthma, recurrent infection of throat, flatulence, dyspepsia, respiratory diseases, analgesic, carminative, sedative, insomnia, epilepsy, abortifacient (Rao *et al*. 1999). The dried roots, as well as the immature and mature fruits, are used extensively, along and in combination with other plant drugs to treat a broad range of ailments in traditional Indian medicine. The dried roots and thicker stems, known commercially as Piplamul, are an important drug in the Ayurvedic and Unani systems. The roots and fruits are used to treat dysentery and leucoderma, as a cholagogue for treating bile duct and gall bladder obstruction, and as a counter-irritant and analgesic for relieving muscular pains and inflammations. A decoction of the dried immature fruit and root, or the powdered fruits mixed with honey, is used to treat chronic bronchitis, cough and cold (Parrotta 2001). An infusion of the powdered fruits is given to women after childbirth to check bleeding and fever. It is an important ingredient in medicated oil used exter-

nally for sciatica and paraplegia (Parrotta 2001).

Phytochemicals: cepharadione A, cepharadione B, cepharanone B, aristolactam AII, norcepharadione B, 2-hydroxy-1-methoxy-4H-dibenzo[*de,g*]quinoline-4,5(6H)-dione, piperolactam A, piperolactam B, piperadione (Desai *et al*. 1988), piperlongumine (Chatterjee and Dutta 1967; Kyung *et al*. 2004; Kim *et al*. 2006a), amides (Wu *et al*. 2004), ethyl 3′, 4′,5′-trimethoxycinnamate, tridecyldihydro-*p*-coumarate, eicosanyl-(*E*)-*p*-coumarate, alkamides, pergumidiene, brachystamide-B, piperderdine, pellitorine, (+)-sesamine and 3-(3′,4′,5′-trimethoxyphenyl)-propionic acid (Das *et al*. 1998a, 1998b), piperidine (Lee *et al*. 2005), pipernonaline and piperoctadecalidine (Park *et al*. 2002), guggulsterone-*E* and guggulsterone-*Z* (Padmaja *et al*. 2002), piperine (Chauhan *et al*. 1998; Khajuria *et al*. 1998; Bajad *et al*. 2002; Selvendiran *et al*. 2006), pellitorine and dihydropiperlonguminine (Sarma *et al*. 2006), few monoterpene hydrocarbons, sesquiterpenes, high content of aliphatic hydrocarbons, caryophyllene oxide, β-caryophyllene (Tewtrakul *et al*. 2000), guineensine (Seung *et al*. 2004), thymoquinol, 6-hydroxydopamine (Mouhajir *et al*. 2001), retrofractamide-A (Parmar *et al*. 1998), 3-(3′-4′-5′-trimethoxyphenyl) propionic acid (Srinivasa Reddy *et al*. 2001), Isodihydropiperlonguminine, phenyl propanoic acid derivatives (Anuradha *et al*. 2004), piperoctadecalidine (Lee *et al*. 2002), β-caryophyllene, pentadecane, *p*-bisabolene, starch, (Shankaracharta *et al*. 1997), (2*E*,4*Z*,8*E*)-*N*-[9-(3,4-methylenedioxyphenyl)-2,4,8-nonatrienoyl] piperidine, retrofractamide C, pipernonaline, piperrolein B, and dehydro-pipernonaline (Seung *et al*. 2006), pipernonaline, piperettine (Yang *et al*. 2002).

Ethnopharmacy: A decoction of the dried immature fruit and root mixed with honey is used to treat chronic bronchitis, coughs and colds. An infusion of the powdered fruit is given to women after childbirth to check bleeding and fever. It is an important ingredient in medicated oil used externally for sciatica and paraplegia (Parrotta 2001).

Conservation measures: Soniya and Das (2002) developed an efficient and rapid tissue culture protocol for *P. longum*, through shoot tip multiplication and direct regeneration. Multiple shoots were induced from shoot tips cultured on MS medium containing 4.44–22.19 µM BA and 4.64–13.9 µM KN. Maximum number of shoots were induced with 8.9 µM BA and 4.64 µM KN. Adventitious shoot regeneration from leaf segments was achieved on MS containing 3.6–22.19 µM BAP along with 3.31–12.4 µM Picloram (Pic). Shoot differentiation occurred directly from the leaf bases without intermediate callus formation. Maximum shoot buds were obtained on MS medium with 17.76 µM BA and 8.28 µM Pic. Elongated shoots were separated and rooted in MS supplemented with 2.46 µM IBA. Plantlets, thus developed were established in soil. Philip *et al*. (2000) observed the genotypic and morphogenetic differences among three female varieties of *P. longum*, were investigated for the development of a common and efficient method of plant regeneration. RAPD analysis, using random oligonucleotide primers, revealed that these varieties are genetically different. Compared to the Assam variety, Viswam and Calicut varieties are genetically similar (95%) among themselves. Leaf explants from different varieties exhibited maximum regeneration potential. Among the types tested, Viswam variety exhibited best morphogenetic response followed by the varieties from Calicut and Assam. An efficient protocol was developed for regeneration from leaf calli of all the three genotypically different varieties. Callus regenerated plants from leaf explants were subsequently rooted, hardened and established on soil under natural conditions of growth.

31. *Piper nigrum* L. - Piperaceae

Trade names: Black pepper; green pepper.

Threat status: Endangered (Jadhav *et al*. 2001).

Medicinal and phytochemical importance: Dried fruits are used for abdominal ulcers, tasteless ness, pimples of puberty, eye diseases, excessive sleep, piles, indigestion, diarrhoea, obesity, eczema and best antidote to any type of poison, vertigo and coma, and a stomachic for dyspepsia (Ravikumar and Ved 2000). Choi *et al.* (2007) reported that the expression of HO-1 by piperine is mediated by both JNK pathway and Nrf2, and the expression inhibits cisplatin-induced apoptosis in HEI-OC1 cells. In the Rho *et al.* (2007) study via a bioactivity-guided fractionation of MeOH extracts of the fruits of *P. nigrum*, five alkamides were isolated used in inhibition of cholesterol esterification in rat liver and HepG2 cells. Lin *et al*. (2007) reported that *P. nigrum* fruit water extract and its main alkaloid, piperine, promote melanocyte proliferation which acts as potential treatment for the depigmentary skin disorder, vitiligo. Chatterjee *et al.* (2007) showed the DNA protecting role of isolated compounds extracted from green pepper at high doses as high as 5 kGy and further suggested the potential use of their extracts as a nutraceutical in preventing oxidative damage to cells. Antioxidant potential of phenolic compounds from green pepper and lignans from fresh mace (*Myristica fragrans*) were evaluated for their ability to scavenge DPPH radical, inhibit lipid peroxidation and protect plasmid DNA damage upon exposure to gamma radiation. Pathak and Khandelwal (2006) reported that piperine acts as anti-oxidative, anti-apoptotic, and restorative ability against cell proliferative mitogenic response and phenotypic alterations by piperine. According to Vijayakumar and Nalini (2006) piperine supplementation markedly protects erythrocytes from oxidative stress by improving the antioxidant status in HFD-fed antithyroid drug treated rats. Methanolic extracts of *P. nigrum* on inhibition of cytochrome CYP2D6 via erythromycin *N*-demethylation and dextromethorphan *O*-demethylation activities in human liver microsomes was screened by Subehan (2006). Selvindiran *et al*. (2006) suggest that piperine may extend its chemopreventive effect through modulating the protein bound carbohydrate levels, as they are one of the indicators of tumorigenesis. Kaleem *et al.* (2005) suggested that oxidative stress plays a key role in diabetes, and treatment with aqueous extract of *P. nigrum* seeds and *Vinca rosea* flowers are useful in controlling not only the glucose and lipid levels but these components may also be helpful in strengthening the antioxidants potential. Venkat Reddy (2004) reported anti-bacterial constituents from the petroleum ether extracts of *P. nigrum*. Toxic effects of natural piperine on *Trypanosoma* parasites were reported by Ribeiro (2004). Siddique *et al*. (2004) reported that the petroleum ether extract of dried ground whole fruits of *P. nigrum* afforded 20 compounds including two new insecticidal amides, named as pipnoohine and pipyahyine, exhibited toxicity against fourth instar larvae of *Aedes aegypti* L. by the WHO method. Matsuda *et al*. (2004) reported that the methanolic extract from the leaves of *P. nigrum* showed a significant stimulatory effect on melanogenesis in cultured murine B16 melanoma cells. According to Ingkaninan *et al*. (2003) the methanolic extract of *P. nigrum* is being used to inhibit Acetylcholinesterase (AChE), which has been used as a drug for the symptomatic treatment of Alzheimer's disease. According to Khajuria *et al*. (2002) it is suggested that piperine may induce alterations in membrane dynamics and permeation characteristics, along with induction in the synthesis of proteins associated with cytoskeletal function, resulting in an increase in the small intestine absorptive surface, thus assisting efficient permeation through the epithelial barrier. Dorman and Deans (2000) reported that the volatile oils of black pepper exhibited considerable inhibitory effects against 25 different genera of bacteria. Limyati and Juniar (1998) showed the plant material constituents of JG (Jamu Gendong) such as rhizomes, leaves, herbs and fruits of *P. nigrum* their antibacterial and antifungal activities. According to Nalini *et al*. (1998), in the presence of a known co-

lon carcinogen, 1,2-dimethyl hydrazine (DMH), the activity of β-glucuronidase was found to be significantly decreased in the distal colon in supplementation with black pepper. The modulatory effect of *P. nigrum* on hepatic detoxication in Swiss Albino Mice was studied by Singh and Rao (1993).

Ethnopharmacy: Tribals used the dried seeds for the treatment of some skin diseases (www.anniesremedy.com/herb _detail45.php).

Conservation measures: Sodium alginate concentration of 4% (w/v) was ideal at a calcium chloride concentration of 100 mM to produce capsules of perfect morphology and sufficient gel strength. Preliminary studies on storage indicated that the somatic embryos encapsulated in 4% sodium alginate can be successfully stored at culture room temperature on agar-gelled Schenk and Hildebrandt (SH) basal salt solution up to 45 days. Storage at low temperature of 4°C was found to be lethal whereas non-encapsulated somatic embryos were not suitable for storage. Possibility of direct sowing of synthetic seeds in the soil was also examined (Nair and Gupta 2007). A high-frequency plantlet regeneration protocol was developed through cyclic secondary somatic embryogenesis. Secondary embryos formed from the radicular end of the primary somatic embryos which were originally derived from micropylar tissues of germinating seeds on growth regulator-free SH medium in the absence of light. The process of secondary embryogenesis continued in a cyclic manner from the root pole of newly formed embryos resulting in clumps of somatic embryos. Strength of the medium and sucrose concentration influenced the process of secondary embryogenesis and fresh weight of somatic embryo clumps. Full-strength SH medium supplemented with 1.5% sucrose produced significantly higher fresh weight and numbers of secondary somatic embryos while 3.0 and 4.5% sucrose in the medium favored further development of proliferated embryos into plantlets. The system of cyclic secondary somatic embryogenesis described here represents a permanent source of embryogenic material that can be used for genetic manipulations of this crop species (Nair and Gupta 2006). When the explants were cultured on growth regulator-free solid SH medium and maintained in the dark, somatic embryos originated from a ring-like tissue on the micropylar region of the seeds. Sucrose concentration of the medium was found to be crucial for the induction of somatic embryos, and 30 g L^{-1} was found to be the optimum. Maturation and germination of somatic embryos were achieved on the same medium. Suspension culture enhanced the process of maturation and germination. Regenerated plants were established in soil. Growth regulators were found to inhibit the induction of somatic embryogenesis (Nair and Gupta 2003). The best establishment and proliferation of shoot tip explants was obtained on MS medium containing 1.5 mg L^{-1} BAP alone; subsequent growth and development of lateral branches was best on media containing 1.5 mg L^{-1} BAP and 3.0 mg L^{-1} IBA. Adenine sulphate inhibited the number of explants showing regeneration but increased the number of shoot buds per regenerating explant. Shoots were rooted on a 50% strength medium containing 1 mg L^{-1} NAA (Philip *et al.* 1992).

32. *Plumbago rosea* L. - Plumbaginaceae

Trade name: Rosy-flowered leadwort; Fire plant.

Threat status: Endangered (Jadhav *et al*. 2001).

Medicinal uses: Plumbagin has been identified and commercially exploited from *P. rosea*. Plumbagin act as immunomodulator, antispasmodic, anticancer, antimicrobial, antiviral, anti-inflammatory, antioxidant and are used for curing various infectious diseases. Plumbagin is also reported to enhance *in vitro* phagocytosis of human granulocytes (Havsteen 1983; Wurm *et al*. 1984; Wagner *et al*. 1986; Finnie and van Staden 1993; Rout *et al*. 1999; Sugihara *et al*. 1999; Jayaram and Prasad 2006a).

Medicinal and phytochemical importance: Plumbagin content accumulated more in roots of *P. rosea* than other two species *P. auriculata* and *P. zeylanica.* Plumbagin is a potential toxic antitumor drug extracted from *P. rosea* (Mallavadhini *et al*. 2002; Panichayupakaranant and Tewtrakul 2002; Sajan *et al*. 2005). Cell cultures of *P. rosea* were immobilized in calcium alginate and cultured in MS basal medium containing 10 mM $CaCl_2$ for the production of plumbagin by Komaraiah *et al.* (2003). Methanolic root extract of *P. rosea* is used by tribal people as an antifertility agent (Sattar *et al*. 2007). The chloroform extract had wound healing activity of plumbagin and has been incorporated into ointments blended with yellow soft paraffin (Saraswathy *et al*. 2006). Ethanolic crude extract of *P. rosea* root extract induced morphological changes of the endometrial surface epithelium in albino rat uterus (Sarma and Mahanta 2000). Mathew *et al*. (2002) investigated the macrofilaricidal property of *P. indica/rosea* against *Setaria digitata*, a filarial parasite of cattle. Ganasoundari *et al*. (1997) Withaferin A (WA), a steroidal lactone, and plumbagin (Pi), a naphthoquinone, from the roots of *Withania somnifera* and *P. rosea*, respectively, were shown to possess growth inhibitory and radiosensitizing effects on experimental mouse tumours. Lal *et al*. (1983) reported the antifertility and uterine activity of *P. rosea* in rats.

Ethnopharmacy: Tribals used these roots for the treatment of cough and intermittent fever (Parrotta 2001).

Conservation measures: Nodal explants when cultured in MS agar medium containing 3% sucrose and 15.4 μM BAP remained contamination free and responded at 95% rate with callusing at basal cut end and axillary bud break in 5 days followed by the formation of 2.41 ± 0.14 shoots of 0.87 ± 0.14 cm length in 3 weeks. Extensive callus proliferation from the cut basal end overlapped the 8.2 ± 0.37 axillary shoots/buds formed after 7 weeks. Division of the shoot cluster and transfer of 2-3 shoots (0.5-1.5 cm) in a clump to MS basal liquid medium induced elongation of the shoots to 4.1 ± 0.18 cm in 2 weeks. *In vitro* rhizogenesis in presence of 0.49 μM IBA is recommended for enhanced rooting and high yield of commercially important tuberous roots during cultivation in the field (Jose *et al.* 2007). In the combination of BAP (1.5 mg L^{-1}) + IAA (0.5 mg L^{-1}), nodal explants produced 20-25 shoots without the intervention of callus. Shoots obtained *in vitro* produced 4-6 roots in the same medium without being transferred to the rooting medium. However, when the shoots were transferred to the medium supplied with IBA (1.5 mg L^{-1}) number of roots increased to 6-8 (Harikrishnan and Hariharan 1996). When stem, leaf and root explants were used in a hormonal regime of 2.5 mg L^{-1} BAP and 1.5 mg L^{-1} NAA with the formation of nodular callus in 4 weeks and the callus was divided and subcultured at 4-week intervals in the presence of 3.0 mg L^{-1} BAP to produce up to 23.5 ± 1.6 shoots in 18 weeks and then at 2.0 mg L^{-1} BAP to produce up to 79.6 ± 1.5 shoots in 23 weeks. The shoots of 2.0-3.5 cm length were rooted easily in half-strength MS agar medium supplemented with 0.1 mg L^{-1} IBA and rooted plants established within 4 weeks at a 95-98% rate without hardening. During this period, the concentration of the root-specific compound, plumbagin recorded per g dry weight (1.5%), was higher than that of conventionally propagated plants (0.9-1.0%). The early formation of plumbagin-rich tuberous roots holds significant potential for the commercial cultivation of the micropropagated plants (Satheeshkumar and Seeni 2003). Optimum callus formation was achieved on semi-solid MS medium supplemented with 0.25 mg L^{-1} KN and 2.0 mg L^{-1} NAA. Somatic embryogenesis was achieved upon transferring the 4-week-old callus to a medium containing 1.0 mg L^{-1} KN, 0.5 mg L^{-1} GA_3 and 0.1 mg L^{-1} NAA. Embryo maturation and germination was achieved on half-strength MS

Table 18 *Pterocarpus marsupium*: Medicinal importance.

Parts used	Medicinal properties
Bark	Asringent, toothache.
Gum	Anti pyretic, anthelimintic, liver tonic, leucoderma, urinary disorders, dysentery, diarrhoea, diabetes mellitus.
Leaves	Boils and sores.
Flowers	Anorexia.
Heart wood	Leprosy and skin diseases.
Bark paste	Ring worm disease.
Leaves paste	Boils and skin diseases.
Wood powder	Leprosy, skin diseases, diarrhoea, dysentry, hemophilic disorders, astingent, rectalgia, rectitis, ophthalmology, gout, bronchitis, verminosis, pharyngitis.
Wood + bark brew	Astringent, toothache.
Wood + aqueous extract	Anti diabetic.
Boiled stem bark	Restoration/tonic after childbirth.
Stem wood paste	Ringworm disease.
Wood powder + dust + leaves	Itches, scabies, boils, leucoderma, leprosy, skin diseases, sores.
Wood chips + water	Diarrhoea, leucoderma.
Bark powder	Diabetes among tribals.
Flowers	Fever.

basal salts supplemented with 0.01-0.25 mg L^{-1} KN and 2% (w/v) saccharose. Average of 50-60 plantlets were obtained from 150 mg of embryogenic callus within 4 weeks of subculture. Out of the 50 plantlets about 28 survived in the greenhouse (Das and Rout 2002).

33. *Pterocarpus marsupium* Roxb. - Papilionaceae

Trade name: Indian kino tree.

Threat status: Vulnerable (Reddy *et al*. 2001).

Medicinal importance: Seeds are reported to cure cataract, wood powder is used to treat hypoglycemia, leucamia, etc. (Kar *et al*. 2003). The medicinal importance of the tree species is given in **Table 18**. The various phytochemicals and their importance are enlisted in **Table 19**.

Ethnopharmacy: Tribals use the powdered bark, soak overnight in water and drink to cure diabetes and toothache (Parrotta 2001).

Conservation measures: Studies on micropropagation of *P. marsupium* were carried out by using different hormones in MS media and other media used for tree species like McCown's, B_5. *In vivo* and *in vitro* seed germination studies were carried out by using hormones in MS media alone and in combination. The *in vitro* clonal multiplication has been carried out using various explants as enlisted in **Table 20**.

34. *Pterocarpus santalinus* L. f. - Papilionaceae

Trade name: Red sandalwood, red sanders.

Table 20 *In vitro* clonal multiplication of *Pterocarpus marsupium*.

Media composition and explant	Response	Reference
Cotyledonary node:		
MS medium containing 2.22-13.32 µM BAP or 2.32-13.93 µM KN alone or in combination with 0.26 µM NAA.	Multiple shoots	Chand and Singh 2004
Nodal segments:		
MS, B5 and WH, each supplemented with 3.0 mg L^{-1} BAP and 0.5 mg L^{-1} NAA and MS media supplemented with 0.2 mg L^{-1} IBA. Seed germination improved in all the media studied except for MS.	Multiple shoots	Tiwari *et al*. 2004

Abbreviations: BAP: 6-benzylaminopurine; B5: Gamborg's medium; IBA: indole-3-butyric acid; KN: kinetin; MS: Murashige and Skoog medium; NAA: α-naphthaleneacetic acid; WH: McCown's medium.

Threat status: Endangered (Ravikumar and Ved 2000). Over exploitation, habitat destruction and environmental influences are the main causes of threat (Ahmad and Nayar 1984).

Medicinal and phytochemical importance: The various phytochemical constituents isolated from different parts are mentioned in **Table 21**. *In vitro* clonal propagation methods are mentioned in **Table 22** (Padmalatha and Prasad 2006d). See **Table 23** for the ehnopharmacological response of various constituents isolated from different plant parts.

Ethnopharmacy: All the parts of the plant are useful. The bark extracts showed anti hyperglycemic activity (Parrotta 2001).

Conservation measures: During 2001-2004 field seasons a total of 300 plants were collected from 30 different locations of Andhra Pradesh and one location from Kerala and planted in the field experimental site in University of Hyderabad. Germplasm in the form of seeds was stored in seed bank. Studies on seed germination, micropropagation, morphological and molecular diversity analysis was carried out for accessions collected from various locations (Padmalatha 2005; Padmalatha and Prasad 2007b, 2007c).

35. *Pueraria tuberosa* DC - Papilionaceae

Trade name: Indian kudzu; tuberous honey suckle.

Threat status: Vulnerable (Reddy *et al*. 2001).

Medicinal importance: The tubers are used to treat dysuria, cough, rheumatism, erysipelas and malarial fever, improve voice, promote breast milk secretion, semen production, urinary discharges, blood diseases, biliousness, leprosy, general debility, bronchial asthma, intermittent fever, haemorrhage and the roots are used to cure swollen joints, relieve fever and rheumatism, contraceptive (Prakash *et al*. 1984) emetic and tonic. They also act as antioxidants (Pandey *et al*. 2007).

Table 19 Response of various chemical constituents isolated from different parts of *Pterocarpus marsupium*.

Part used	Chemical constituent	Response	Reference
Wood	Pterostilbene	Hypoglycemia in dogs.	Jahromi and Ray 1993
	Flavonoid	Antidiabetic.	Jahromi and Ray 1993
Bark	Epicatechin, marsupol	Antidiabetic, insulin release.	Ahmed *et al*. 1991b
	Marsupin/Pterostilbene	Hypoglycemia, hypolipidemic.	Sepaha and Bose 1986; Mankani *et al*. 2005
	Pyrocatechin	Astringent; checks the flow of blood.	Sepaha *et al*. 1986
Roots	Pterosupin	Medicinally important.	Chopra *et al*. 1956
Seeds	Hypaphorin	Feeding deterrent.	Janzen *et al*. 1982
Bark	Pterocarposide	Antidermatic, fever.	Handa *et al*. 2000
	Propterol	Antibacterial.	Mathew *et al*. 1984
	Phenolics	Antihyperglycemic.	Manickyam *et al*. 1997

Table 21 *Pterocarpus santalinnus*: Parts used, alkaloids and their medicinal importance

Part used/ Alkaloid	Medicinal uses	References
Wood powder	Astringent, antipyretic, anthelmintic, antiperiodic, diaphoretic, alexeteric, spider poisoning, freckles, defects of vision, bone fractures, leprosy, scorpion sting, hiccough, ulcers, general debility, mental aberrations, bleeding piles, vomiting, eye diseases, headache, haemophilic disorders, inflammation, blood purifier, skin diseases, fever, toothache, hemicrania.	Manjunatha 2006
Wood + bark brew	Chronic dysentry, worms, blood vomiting, weak vision, hallucination.	Anonymous 1969
Wood + fruit extracts	Astringent, diaphoretics, inflammations, headache, skin diseases, bilious infections, chronic dysentery.	Parrotta 2001
Wood powder + dust	Fish preservative.	Parrotta 2001
Wooden chips + water	Diabetes.	Parrotta 2001
Stem bark powder + soft porridge	Diarrhoea.	Parrotta 2001
Bark powder	Astringent, blood purifier, anthelmintic, antipyretic, antidiabetic, curing arecanuts.	Parrotta 2001
Condensed bark powder	0.38-0.45% of mild smelling essential oil.	Parrotta 2001
Condensed bark powder + alcoholic HCl (extraction solvent)	1.98-2.25% of mild smelling essential oil.	Parrotta 2001
Distill of wood	Medicine for heart diseases, blood purifier.	Kameswararao *et al*. 2001
Fruit decoction	Astringent, tonic, chronic dysentery.	Parrotta 2001
Pods decoction	Astringent, tonic, chronic dysentry, psoriasis.	Parrotta 2001
Santalin	Colouring pharmaceutical preparations, food stuffs, high class alcoholic liquors, paper pulp, etc.	Siva 2007
Roots and stumps	Dyeing cotton and leather, staining woods.	Siva 2007

Table 22 *In vitro* clonal multiplication of *Pterocarpus santalinus*.

Explant	Medium composition	VP/SG/MSM	Reference
Node	MS + 250 mg L^{-1} ascorbic acid + 50 mg L^{-1} citric acid + 4.4 µM BAP + 2.2 µM TDZ.	MSM	Prakash *et al*. 2006
Cotyledons	MS + NAA (0.1 mg L^{-1}), BAP (1 mg L^{-1}) and KN (1 mg L^{-1}).	MSM	Arokiasamy *et al*. 2000
Cotyledonary callus	MS + 3 µM BAP.	MSM	Patri *et al*. 1988
Mesocotyl	B-5 medium + 3.0 mg L^{-1} BAP + 1 mg L^{-1} NAA.	MSM	Anuradha and Pullaiah 1999
Shoot tips	MS + 0.2 mg L^{-1} BAP and 0.1 mg L^{-1} KN	MSM	Lakshmisita *et al*. 1992
Seeds	400 mg L^{-1} KN.	SG	Naidu and Rajendrudu 2001
Stem cuttings	IAA, IBA, NAA. At lower concentrations these hormones are used only for inducing rooting but not multiple shoots. Hence it is used in vegetative propagation.	VP	Reddy and Srivasuki 1990

Abbreviations: BAP: 6-benzylaminopurine; B5: Gamborg's medium; IBA: indole-3-butyric acid; KN: kinetin; MSM: Murashige and Skoog medium; NAA: α-naphthaleneacetic acid; TDZ: thiaduron; VP: Vegetative propagation.

Table 23 Response of various chemical constituents isolated from different parts of *Pterocarpus santalinus*.

Part used	Chemical constituent	Response	Reference
Bark (methanolic)	-	Induction of apoptosis.	Kwon *et al*. 2006
Bark (methanolic)	Galactosamine	Hepatoprotectant.	Dhanabal *et al*. 2006
Bark (ethanolic)	Ibuprofen	Gastroprotectant.	Narayan *et al*. 2005
Wood	Aurone glycosides	-	Kesari *et al*. 2004
Callus	Pentacyclic triterpene (3-ketooleanane)	-	Krishnaveni and Srinivasarao 2000a
Heartwood	Isoflavone	-	Krishnaveni and Srinivasarao 2000b
Heartwood	Savinin	Inhibits TNF-α.	Cho *et al*. 2001
Leaf and stem bark	-	Antibacterial.	Manjunatha 2006
Wood (ethanolic extracts)	-	Thermodynamic studies.	Gulrajani *et al*. 2003
Wood	Coumarin glycosides	-	Singh *et al*. 1992

Phytochemicals: A novel chalcane derivative, puetuberosanol deduced as 3′-hydroxy-4′-phenoxy-α, β-epoxychalcan-α′-ol was isolated from the tuber (Khan *et al*. 1996).

Ethnopharmacy: Tribals used the plant peeled and bruised roots as a plaster for swollen joints, crushed and rubbed on the body and also used to relieve fever and rheumatism (Negi *et al.* 2003).

36. *Rauvolfia serpentina* (Linn.) Benth ex. Kurz - Apocynaceae

Trade name: Sarpagandha, Serpentine root, snake root.

Threat status: Endangered (Rao *et al*. 2004).

Medicinal and phytochemical importance: The medicinal and phytochemical importance of various parts is enlisted in **Table 24**.

Ethnopharmacy: Tribals used the roots for anti-hypertension, anti-migraine and an external application for chronic skin diseases (Krishnaraju *et al*. 2005). The tribal inhabitants use the powdered roots orally as an antidote to snake venom. The extracts of the roots are valued for treatment of intestinal disorders, particularly diarrhoea and dysentery and also as an anthelminthic. Mixed with other plant extracts, they have been used for treating cholera, colic and fever. A decoction of the roots is believed to stimulate uterine contractions and is recommended for use in difficult cases of childbirth. The juice of the leaves has been used as a remedy for opacity of the cornea. A drug prepared from the dried fruit, black pepper and ginger is used to regularize menstruation (Parrotta 2001).

Conservation measures: Nodal segments and shoot apices are used as explants with a media combination of MS + 1.0 mg L^{-1} BAP and 0.1 mg L^{-1} NAA (Sarker *et al*. 1996). Work carried out in our laboratory: Interpopulation diversity analysis of 6 accessions collected from Andhra Pradesh District was carried out by using RAPD markers. Intrapopulation diversity was checked by collecting plants from a single location and carrying out RAPD analysis on the germplasm (Padmalatha and Prasad 2007a).

Table 24 Response of various chemical constituents isolated from different parts of *R. serpentina*.

Part used	Chemical constituent	Response	Reference
Cell lines (*str* and *tdc* transformed)	Monoterpene indole alkaloids	Arsenal, therapeutic, industrial, agricultural.	Pasquali *et al*. 2006
Cell lines	Strictosidine β-D-glucosidase	Helps in biosynthetic pathways.	Barleben *et al*. 2005
Cell lines	Vinorine synthase	Helps in the synthesis of ajmaline.	Ma *et al*. 2004
Methanolic root extract	Anhydronium bases	-	Wachsmuth and Matusch 2002
Microsomal cell suspension cultures	Deoxysarpagine hydroxylase	-	Yu *et al*. 2002
Cell suspension cultures	Arbutin synthase	Multifunctional.	Hefner *et al*. 2002
Cell suspension cultures	Vomilenine Reductase	Helps in biosynthesis of antiarrhythmic alkaloid ajmaline.	Schumann *et al*. 2002
Roots	-	Hypnotic, sedative, reducing blood pressure, central nervous system disorders (psychic, motor, anxiety, psychosis, schizophrenia, epilepsy, stress, depression), insomnia, giddiness, dyspepsia and vitiated conditions of kapha and vata, malaria, fever.	Parrotta 2001
Root powder	-	Antidote to snake venom, insect sting, rat bite and poisons.	Parrotta 2001
Root extract	-	Abdominal pains, diarrhea, dysentery, anti helminthic, laxative, diuretic, thermogenic.	Parrotta 2001
Root extract + other plant extracts	-	Cholera, colic and fever, wounds, strangury.	Parrotta 2001
Root decoction	-	Helps in child birth.	Parrotta 2001
Leaf extract	-	Opacity of the cornea.	Parrotta 2001
Dried fruits + black pepper + ginger	-	Regulates menstruation.	Parrotta 2001
	Rescinnamine	Hypertension, psychiatry disorders.	Parrotta 2001
	Ajmaline	Cardiac, arrhythmic.	Parrotta 2001
	Ajmacline	Circulatory diseases.	Parrotta 2001

37. *Rauvolfia tetraphylla* L. - Apocynaceae

Trade name: Snake root.

Threat status: Endangered (Jadhav *et al.* 2001).

Medicinal and phytochemical importance: The roots contain reserpine which can be used as a hypotensive agent, and also used as a substitute/adulterant, the plant extract along with castor oil is used to treat chronic and refractory skin diseases and bark decoction is used to cure chronic skin diseases, destroys parasites (Anitha and Ranjithakumari 2006a, 2006b). The leaf and callus extracts (chloroform) is used as an antimicrobial agent (Shariff *et al*. 2006).

Ethnopharmacy: The decoction of the bark is used as an external application for chronic skin diseases to destroy parasites. *R. tetraphylla* is one of the 17 plant extracts traditionally used in Guatemala for the treatment of blood disorders and parasitic infections (Villar *et al*. 1998).

Conservation measures: *In vitro* flower bud production and induction using combination of hormones BAP and GA (4.44 µM of BAP with 4.3 µM of GA_3) was reported by Anitha and Ranjithakumari (2006c). Rapid *in vitro* shoot proliferation was possible from nodal explants using MS medium with 5 µM TDZ (Faisal *et al*. 2005). Work carried out in our laboratory: Genetic diversity analysis was carried out by using RAPD markers among the seven accessions collected from Andhra Pradesh. 51.6% of polymorphism was revealed, which shows that there is wide range of polymorphism among the collected accessions, and such variation would facilitate their use in various conservational management practices (Padmalatha and Prasad 2006b).

38. *Santalum album* L. - Santalaceae

Trade name: Sandalwood tree.

Threat status: Vulnerable (www.iucn.org).

Medicinal importance: The medicinal properties of *Santalum album* are listed in **Table 25**.

Table 25 *Santalum album*: Medicinal properties (Parrotta 2001)

Parts used	Medicinal properties
Wood	Incense, made into a paste and applied to the forehead in hindu religious ceremonies.
Heartwood	Santal oil.
Roots	Cooling, sedative, diaphoretic, resolvent, tonic, diuretic, ulcers and expectorant properties.
Wood paste	Skin diseases, relieve burns, ally heat, relieve headache, fever.
Decoction of wood	Haemorrhoids.
Sandalwood oil	Gonorrheal urethritis and cystilis, perfumes, cosmetics, facial pimples, skin diseases.

Phytochemicals: Jones *et al.* (2006) proceeded with a chemotaxonomic approach to investigate biosynthetic relationships between heartwood sesquiterpenes in Indian sandalwood, *S. album*. Strong, linear relationships exist between four structural classes of sesquiterpenes; α- and β-santalenes and bergamotene; γ- and β-curcumene; β-bisabolene and α-bisabolol and four unidentified sesquiterpenes. Kim *et al.* (2006b) reported the isolation of three new neolignans and a new aromatic ester, along with 14 known components. Aqueous and methanolic extracts of *Santalum album* were showing antibacterial activity (Parekh *et al.* 2005).

Ethnopharmacy: Tribals used the bark for treating Malaria and the oil obtained from the heartwood of the tree is used in dysuria, cystitis, gynorrhea and cough (Ravikumar and Ved 2000).

Conservation measures: Rapid mass propagation was induced using nodal explants in MS medium with 0.53 µM NAA and 11.09 µM BAP and *in vitro* root induction was achieved from microshoots pulsed with 1230 µM IBA for 30 min in soilrite rooting medium (Sanjaya 2006a, 2006b). Induction of adventitious shoot buds from leaf explants were successfully developed by Mujib (2005). *In vitro* regeneration of plants from mature zygotic embryos through direct somatic embryogenesis was reported by Ravishankar and McComb (2002).

39. *Saraca asoka* (Roxb.) De Wilde - Caesalpiniaceae

Trade name: Asoka tree.

Threat status: Critically endangerd (www.iucn.org).

Medicinal importance: The decoction of bark is used to cure uterine affections and gynecological problems, seeds are used for suppression of urine and calculus and the flowers are used to cure dysentery (Parrotta 2001). Propagation by seeds is quite easy and the tree grows well in most gardens. After soaking the seeds in water for 12 hrs they are sown directly in beds. The seeds germinate within 20 days. Then the seedlings are transplanted in poly bags to the field and planted at a spacing of 3 m (Mathew *et al*. 2004). Extracts of *S. asoca* bark and pure compounds isolated from the bark were tested for properties of menorrhagia (Middelkoop and Labadie 1985).

Phytochemicals: Lyoniside, nudiposide, 5-methoxy-9-β-xylopyranosyl-(-)-isolariciresinol, icariside E_3, schizandriside, (-)-epicatechin, epiafzelechin-(4β→8)-epicatechin and procyanidin B_2, β-sitosterol glucoside (Sadhu *et al*. 2007), leucoanthocyanidins (Duggal and Misra 1980).

Ethnopharmacy: Tribals used this plant leaves as blood purifier and leaf juice is mixed with cumin seeds are used for treating stomachache (Kapoor 2001).

Conservation measures: The germplasm in the form of plants was collected from different locations of Andhra Pradesh and the DNA isolation protocol was standardized in the laboratory (Padmalatha and Prasad 2006a).

40. *Schleichera oleosa* (Lour.) Oken - Sapindaceae

Trade names: Ceylon oak tree; lac tree; Macassar oil tree.

Threat status: Indeterminate.

Medicinal importance: The bark is used as an astringent, to cure back pain, inflammations, ulcers and malaria. The seed oil is used to cure leprosy, skin diseases, rheumatism and burns (Iwasa 1997). Pettit *et al*. (2000) isolated seven cancer cell growth inhibitory hydroxylated sterols from *S. oleosa.*

Phytochemicals: Sehleicherastatins 1-7, schleicheols 1 and 2 (Pettit *et al*. 2000)

Ethnopharmacy: Tribals used the seed oil as an efficient stimulating agent for the scalp both for cleansing and promoting hair growth (Parrotta 2001).

Conservation measures: Natural regeneration is by seed and root suckers. Propagation is by direct sowing in thoroughly prepared soil or by stump planting (Iwasa 1997). The germination of seeds, when placed at 26°C and following decortication, improved by 31.7%. The germination index improved showing that seeds are light sensitive (Sun *et al.* 2002). Studies on blooming, fruiting and breeding were carried out, and seeds mature from the end of July to the middle of August at Nanjing. The testa should be broken to aid germination (Li *et al.* 2003).

41. *Sterculia urens* Roxb. - Sterculiaceae

Trade name: Gum karaya.

Threat status: Citically endangered (Jadhav *et al.* 2001).

Medicinal uses: The leaves are used for activating parturition and source of vitamin A, pleuro-pneumonia in cattle, bark gum is used to treat Lozenges, emulsions, lotions, sprays and pastes, throat infections and juice of bark is used to treat piles. *S. urens* yields gum known as Gum Karaya or Kadaya or Indian Tragacanth which resembles Gum Tragacanth from *Astragalus* spp. and has been long used as substitute and adulterant of the latter. Gum obtained from Gum Karaya plants is used as adhesive, preparations of ice creams, chocolates, sweets, toothpastes, in the manufacture of glazed paper textiles, medicines, paints. It has high demand for industries viz. food, pharmaceuticals, textiles, leather, oil exploration. It contains approximately 8% acetyl groups in two regions viz., I and II in the polysaccharide chain. The general structure appears to consist of an elongated framework with a multiplicity of ionisable acidic groups interspersed with hydrophobic regions provided by the methyl groups of the ramnose units and in the native gum, of acetyl groups (OAc). It contains relatively rigid ordered domains of high intramolecular attraction and more flexible less associated domains due to the order-destroying effect of bulky side chains that readily entrain water molecules. The gums exhibit different physico-chemical characteristics and properties depending upon the source of origin and harvesting process. Gum karaya is listed as 'generally regarded as safe' (=GRAS) as a food stabilizer in the USA. Gum Karaya is confused with Gum Kaitra from *Cochlospermum religiosum*. In Andhra Pradesh, it grows wild in the rocky terrain of the Khammam District. It is a fast vanishing economically important plant. It is one of the least water soluble exudation gums. Leaves and tender shoots produce mucilage and is used in preparation of medicines for pleuropneumonia in cattle (Sunnichan *et al.* 1998).

Conservation measures: *In vitro* propagation of *S. urens*, using cotyledonary nodal segments on MS medium containing 2.0 mg L^{-1} BAP was established by Purohit and Dave (1996). Sunnichan *et al.* (1998) reported adventitious shoot formation using nodal explants in MS + 6.6 μM BAP and somatic embryogenesis from nodular callus of hypocotyl explants in MS + 4.52 μM TDZ.

Phytochemicals: Galactose, rhamnose galacturonic, glucuronic acids, xylose (Brito *et al*. 2004), ascorbic acid, tannin (Kunbhare and Bhargava 1999), flavonol glycosides (Khatoon *et al*. 1989).

Ethnopharmacy: Tribals used the gum with sugar candy to relieve diarrhoea and dyspepsia (Nair *et al.* 1995).

42. *Strychnos nux-vomica* L. - Loganiaceae

Trade name: Nux vomica (www.hebatboy.com).

Threat status: Indeterminate.

Medicinal uses: Mostly the seeds, bark and roots exhibit analgesic and anti-inflammatory (Yin *et al*. 2003), antidiarrhoeal potential (Shoba and Thomas 2001), anti tumor (Deng *et al*. 2006), hypouricaemic activities (Umamaheswari *et al*. 2007). Pharmacological effects on several neurotransmitter receptors, including some members of the super family of ligand-gated ion channels (Jensen *et al*. 2006) were also reported.

Phytochemicals: Galactomannan and galactan (Adinolfi *et al*. 1994), strychnine, α- and β-colubrines, brucine, pseudostrychnine, pseudobrucine, vomicine, and novacine (Galeffi *et al*. 1969), icajine (Bisset and Fouché 1968), isostrychnine (Galeffi *et al*. 1974), brucine *N*-oxide (Yin *et al*. 2003), isostrychnine (Deng *et al*. 2006), 4-hydroxystrychnine, *N*-methyl-sec.-pseudo-β-colubrine, cantleyine, loganin, secologanin (Bisset and Choudhury 1974), salidroside, cuchiloside (Bisset *et al*. 1989), protostrychnine (Baser *et al*. 1979), 15-hydroxystrychnine (Galeffi *et al*. 1979), strychnine *N*-oxide, 16-hydroxy-α-colubring, 2-hydroxy-3-methoxystrychnine, isobrucine, isobrucine-*N*-oxide, isostrychnine-*N*-oxide (Wu *et al*. 2007), loganin (Frèdèrich *et al*. 2004), 60-*O*-acetylloganic acid, 40-*O*-acetylloganic acid, 30-*O*-acetylloganic acid, loganic acid and 7-O-acetylloganic acid (Zhang *et al*. 2003) were reported from seeds, roots and bark. Powdered leaves are reported to have xanthine oxidase inhibitors (XOI) useful for the treatment of gout (Umamaheswari *et al*. 2007).

Ethnopharmacy: In traditional Indian Medicine the seeds are considered tonic, antidiarrhoeal, antidysentric, antispasmodic, emetic, febrifuge and stimulant and are ingredients of preparations prescribed for a variety of nervous disorders. The leaves are reportedly used as a poultice to promote healing of wounds and maggot infested ulcers. The bark juice is used in the treatment of cholera and acute dysentery and a decoction of the bark is used to treat epilepsy. In Southern Orissa the stem bark ground with lemon juice is made into pills that are taken orally in cases of acute diarrhoea. The juice of fresh wood is reportedly used for treating dysentery, fevers and dyspepsia. The root bark ground into a fine paste with lime juice and made into a pill is considered useful for treating cholera (Parrotta 2001).

Conservation measures: In order to conserve *S. nux-vomica*, germplasm in the form of seeds and seedlings were collected from various locations and conserved in a field gene bank and experimental site (Rao 2007).

43. *Strychnos potatorum* L. - Loganiaceae

Trade name: Nirmali (www.youngever.com).

Threat status: Indeterminate.

Medicinal uses: Seeds are used in the Indian traditional system of medicine in hepatopathy, nephropathy and in curing gonorrhoea, leucorrhoea, gastropathy, bronchitis, chronic diarrhoea, strangury, renal and vesicle calculi, diabetes and eye diseases. Sanmugapriya and Venkataraman (2006) reported hepatoprotective and antioxidant activities whereas antidiarrhoeal activity (Biswas *et al*. 2002), antiulcerogenic (Sanmugapriya and Venkataraman 2007) and diuretic activity (Biswas *et al*. 2001) were also studied.

Phytochemicals: Galactomannan and galactan (Adinolfi *et al*. 1994), harmane carboxamide, cantleyine, 18,19-dihydrousambarensine, polyneuridine, norharmane, akuammidine, nor-C-flurorocurarine, ochrolifuanine A, bisnordihydrotoxiferine, ochrolifuanine E, normacusine B, normavacurine, henningsamine, 11-methoxyhenningsamine, dihydrolongicaudatine, dihydrolongicaudatine Y, antirhine, (20*R*- and 20*S*-dihydroantirhine, 11-methoxy-12-hydroxydiaboline, diaboline, 11-methoxydiaboline, desacetylretuline and diaboline *N*-oxide (Massiot 1992), diaboline (Singh *et al*. 1975) and isomotiol (fern-8-en-3β-ol), sitosterol, stigmasterol and campesterol (Singh *et al*. 1978) were reported from seeds, roots and bark extracts.

Ethnopharmacy: Seeds are reported to be used as a local application in case of eye diseases. They are rubbed along with honey and camphor and the mixture is applied to the eyes to treat copius watering. Pastes of the seeds are reported to be consumed internally along with little tender coconut milk against urinary disorders and retention of urine (Sumy *et al*. 2000).

Conservation measures: In order to conserve *S. potatorum*, germplasm in the form of seeds and seedlings were collected from various locations and conserved in a field gene bank and experimental site (Rao 2007).

44. *Terminalia arjuna* (Roxb.) Wight & Arn. - Combretaceae

Trade name: White murdah.

Threat status: Near threatened (Ravikumar and Ved 2000).

Medicinal uses: *T. arjuna* is an important cardiotonic plant described in Ayurveda. It is also believed to have the ability to cure hepatic disorders, gonorrhea, leucorrhea, tuberculosis, giddiness, urogenital, as a tonic, anthelmintic, styptic and alexiteric venereal and viral diseases (Kumar and Prabhakar 1987). It is useful in urinary tract infections and reduces the burning micturition and because of its diuretic action it was found to be helpful for renal or urinary bladder stones (Scassellati-Sforzolini *et al.* 1999). The effect of bark powder in stable angina pectoris patients on anginal frequency, blood pressure, body mass index, blood sugar, cholesterol and HDL-cholesterol was fairly effective (Dwivedi and Agarwal 1994; Miller 1998) (**Table 26**).

Phytochemicals: Arjunosides III and IV (Anjaneyulu and Ramaprasad 1982), arjunolitin, a triterpene glycoside (Tripathi *et al*. 1992), terminic acid, a dihydroxytriterpene carboxylic acid (Anjaneyulu and Ramaprasad 1983).

Ethnopharmacy: Tribals used the powered bark for gastric troubles, ulcers, scorpion sting (Devi *et al.* 2007).

Conservation measures: Induction of somatic embryogenesis and plant regeneration from leaf callus using MS medium with 5 mg L^{-1} 2,4-D and 0.01 mg L^{-1} KN was reported by Kumari *et al.* (1998). Direct shoot regeneration from mature nodal explants in MS medium with 2 mg L^{-1} BAP was standardized by Thomas *et al.* (2003). Pandey *et al.* (2006) reported the best shoot regeneration and multiplication from nodal explants grown on modified half-strength MS medium containing 4.44 μM BA and 0.53 μM NAA.

Table 26 *Terminalia arjuna*: Bioactive compounds, phytochemical and pharmacological wealth.

Bark exhibits gastroprotective effect on diclofenac sodium-induced gastric ulcer.	Devi *et al.* 2007.
Source of drug for cardiovascular disorders.	Dwivedi *et al.* 2007
Arjunolic acid, a triterpenoid saponin, ameliorates arsenic-induced cyto-toxicity in hepatocytes.	Manna *et al.* 2007
Phytomedicinal activity is reportd on carbon tetrachloride-induced cardiac oxidative stress.	Manna *et al.* 2007
Bark phenolic: Antioxidant activity.	Sultana *et al.* 2007
Colour components isolated.	Bhuyan and Saikia 2005
Useful role in ischaemic mitral regurgitation.	Dwivedi *et al.* 2005
Pharmacological data show that it protects rabbit heart against ischemic-reperfusion injury.	Gauthaman *et al.* 2005
Component of Liv-52, protects liver in cirrhotic patients.	Huseini *et al.* 2005
Contains cardioprotective drug.	Pawar and Bhutani 2005
Antiherpes simplex virus type 2 activity of casuarinin in bark.	Cheng *et al.* 2003
Role in ischemic mitral regurgitation.	Dwivedi *et al.* 2003
Alcoholic extract: Cardioprotective effect on myocardial ischemic reperfusion injury.	Karthikeyan *et al.* 2003
Antiatherogenic effect of Caps HT2, a herbal Ayurvedic medicine formulation.	Mary *et al.* 2003
Oral administration and topical application of alcoholic extract of bark on incision and excision wounds in rats.	Rane and Mengi 2003
Antimutagenic activities of acetone and methanol fractions.	Kaur *et al.* 2002
RP-LC determination of oleane derivatives in *T. arjuna*.	Singh *et al.* 2002
Chronic treatment with bark on the isolated ischemic-reperfused rat heart.	Gauthaman *et al.* 2001
Induction of Hsp72 and augumentation of endogenous antioxidants protects rabbit heart from ischemic reperfusion injury.	Maulik *et al.* 2001
Cardenolide from roots.	Yadav and Rathore 2001
Modulatory effects of tannin fraction on the genotoxicity of mutagens in *Salmonella typhimurium*.	Kaur *et al.* 2000

Table 27 *Terminalia chebula* (constituent of "Triphala" (3 fruits), an ayurvedic rejuvenating drug): Phytochemistry and ethanopharmacological investigations.

Fruits exhinited inhibitory effect on α-glucosidase.	Gao *et al.* 2007
"Triphala" promoted healing of infected full-thickness dermal wound.	Kumar *et al.* 2007
Rich in natural phenolic antioxidants.	Surveswaran *et al.* 2007
Reported to contain depigmenting agents.	Jin *et al.* 2006
Inhibits ruminal methanogenesis.	Kamra *et al.* 2006
Its extract is potent antimethanogenic compound with least effect on rumen.	Patra *et al.* 2006
Chemomodulatory effect against nickel chloride-induced oxidative stress and tumor promotion response in male Wistar rats.	Prasad *et al.* 2006
Chromatographic fingerprint analysis – a rational approach for quality assessment of traditional Chinese herbal medicine.	Xie *et al.* 2006
Microbial transformation of tannin-rich substrate to gallic acid through co-culture method.	Banerjee *et al.* 2005
Antibacterial in Iranian folkloric medicine.	Bonjar *et al.* 2004
Inhibition of Clotrimazole-resistant *Candida albicans*.	Bonjar *et al.* 2004
Potent antioxidant and a probable radioprotector.	Naik *et al.* 2003, 2004
Radioprotective in mice exposed to γ-radiation.	Jagetia *et al.* 2002
In vitro Triphala is antimutagenic.	Kaur *et al.* 2002
Anti-diabetic activity and its relationship with its antioxidant property.	Sabu *et al.* 2002
Inhibition of cancer cell growth by its crude extract (rich in phenolics).	Saleem *et al.* 2002
Triphala – A short review.	Wohlmuth 2002
Antibacterial activity against *Helicobacter pylori*.	Malekzadeh *et al.* 2001
Inhibitory action of its water-soluble fraction on systemic and local anaphylaxis.	Shin *et al.* 2001
Potential of its aqueous extract as an anticaries agent.	Jagtap *et al.* 1999
Possesses antimicrobial properties.	Ahmad *et al.* 1998
Antimutagenicity of hydrolyzable tannins in *Salmonella typhimurium*.	Kaur *et al.* 1998
Hypolipidemic activity demonstrated in experimentally induced atherosclerosis.	Shaila *et al.* 1998
Activity of a crude extract formulation in experimental hepatic amoebiasis and in immunomodulation.	Sohni *et al.* 1996
Prophylactic treatment of cytomegalovirus infection with traditional herbs.	Yukawa 1996
Its extract exhibited anti-HSV-1 activity [Acyclovir (ACV) a selective antiherpetic agent, widely used for the treatment of *Herpes simplex virus* type 1 (HSV-1) and *Varicella zoster* virus infection] without adverse reactions.	Kurokawa *et al.* 1995
The antiamoebic effect of a crude drug formulation against *Entamoeba histolytica in vitro* and *in vivo*.	Sohni *et al.* 1995
Triterpenoids and their glycosides are of therapeutic importance.	Kundu *et al.* 1993
Potential as a food source with nutritive value.	Barthakur *et al.* 1991
2α-Hydroxymicromeric acid, a pentacyclic triterpene.	Singh *et al.* 1990
The Ayurvedic medicines Haritaki, Amla and Bahira reduce cholesterol-induced atherosclerosis in rabbits.	Thakur *et al.* 1988
Used in a variety of traditional medicines.	Arseculeratne *et al.* 1985

45. *Terminalia chebula* Retz. - Combretaceae

Trade name: Gall nut tree, black myrobalan.

Threat status: Indeterminate.

Medicinal uses: The fruit is mostly used as a laxative and anthelmintic, digestive, carminative, stomachic, tonic, expectorant, anthelmintic, antidysenteric, ulcers, swellings, skin and eye diseases, diabetes, chronic and recurrent fever, anemia, cardiac disorders, diarrhoea, dysentery, cough, dyspnoea, ripe fruit to treat astringency, ophthalmia, spleen diseases, piles and fruit pulp is used for treating bleeding gums, stomatitis (Kirtikar and Basu 1993; Suguna *et al.* 2002). Saleem *et al.* (2002) reported that the crude phenolic extracts of *T. chebula* having inhibiting the cancer cell growth property. The hydrolysable tannins extracted from *T. chebula* having exhibiting anti mutagenic activity in *Salmonella typhimurium* (Kaur *et al.* 1998). Increased gastric emptying capacity using *T. chebula* was reported by Tamhane *et al.* (1997) (**Table 27**).

Phytochemicals: Two new triterpenoid glycosides, chebulosides I and II were isolated from the stem bark and shown to be β-D-galactopyran (Kundu and Mahato 1993), 2α-hydroxymicromeric acid, a pentacyclic triterpene were isolated (Chandansingh 1990).

Ethnopharmacy: Tribals used the fruit for healing wounds, ulcers and swellings, to treat skin and eye diseases. The unripe fruits used in astringent, opthalmia and spleen diseases (Khare 2004).

Conservation measures: Multiple shoot induction was developed from cotyledonary explants using half-strength MS with 0.3 mg L^{-1} GA_3 + 1.0 mg L^{-1} IBA + 10.0 mg L^{-1} BAP after 4 weeks of culture (Shyamkumar 2003). Somatic embryogenesis were initiated using mature zygotic embryo callus cultures on induction medium containing MS medium with 1.0 mg L^{-1} 2,4-D either 0.01 or 0.1 mg L^{-1} KN (Anjaneyulu *et al.* 2004). Kanwar *et al.* (2007) placed shoot buds of 5-year old trees on woody plant medium supplemented with 0.8 mg L^{-1} BAP for establishment of buds and 1.50 mg L^{-1} BAP + 0.05 mg L^{-1} NAA for shoot proliferation. This was followed by subculturing of nodal segments by removing apical buds on shoot proliferation medium for four times at an interval of four weeks to enhance shoot re-multiplication. Maximum rooting was obtained by pulsing microshoots with IBA (2 mg L^{-1}) in the dark for 2 hours and thereafter culturing them on ½-strength woody plant medium containing 0.1% activated charcoal but without any growth regulators.

46. *Terminalia pallida* Brandis. - Combretaceae

Trade name: White gallnut.

Threat status: Globally Endemic and endangered (Jadhav 2001).

Phytochemicals: Phenolics, steroids, triterpenoids (Gunasekar *et al.* 1993).

Medicinal uses: Fruit and bark used as antipyretic, a purgative, diuretic and against cold and cough, dysentery, diarrhoea, swellings and fever, to cure peptic ulcers, diabetes, venereal diseases, coughs and colds, anti-inflammatory, dysentery, piles (Sudarsanam and Patnaik 1995) and antibacterial (Gupta *et al.* 2002). Antidiabetic activity of the fruit was reported by Rao *et al.* (2003). Anti-ulcer activity of ethanol extract was reported in Swiss albino rats (Gupta *et al.* 2005).

Ethnopharmacy: Tribals used the plant fruits in treating dysentery (Parrotta 2001). Among the Yanadi tribes and local folks, the plant extract is used for treating various ail-

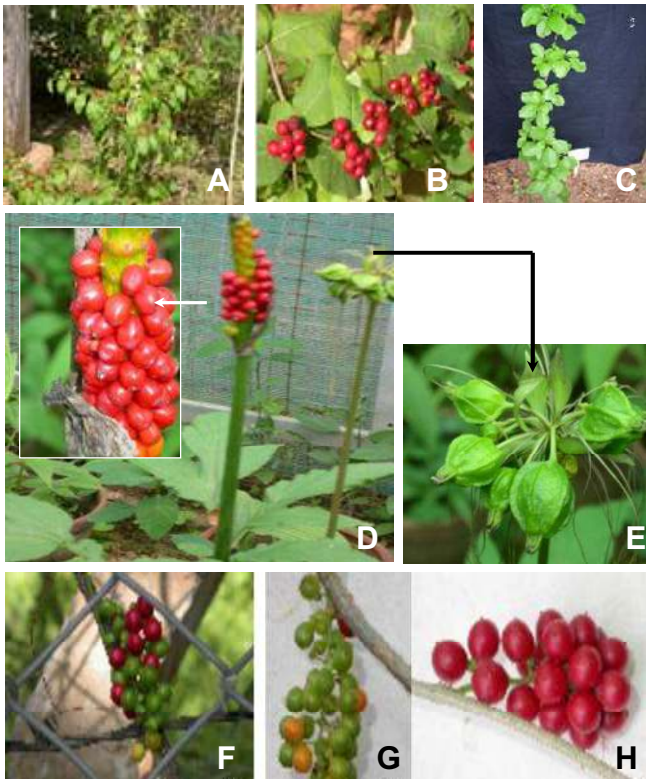

Fig. 13 Selected MAP germplasm in field experimental site. (**A, B**) *Rauvolfia tetraphylla*; (**C**) *Decalepis hamiltoni*; (**D**) *Amorphophallus sylvaticus* (inset shows inflorescence); (**E**) *Tacca leontopetaloides*; (**F-H**) *Tinospora cordifolia* fruits (immature to ripe).

ments as it possess biological activity which inturn was proved by different *in vitro* experiments. The extracts showed marked hypothermic and anti-inflammatory activeties (Sudarsanam and Patnaik 1995). The Adivasi tribes of the Eastern Ghats of Andhra Pradesh use the plant extracts for treating skin diseases (Ram *et al*. 2004).

47. *Tinospora cordifolia* (Willd.) Miers ex. Hook. f. & Thoms - Menispermaceae

Trade name: Gulanshe Tinospara, Gulancha Tinospara, Tinospara, Giloy.

Threat status: Indeterminate.

Medicinal uses: *T. cardifolia* (**Fig. 13F-H**) extract exhibits immunomodulatory (Manjrekar *et al* 2000; Veena *et al.* 2007), acetylcholinesterase inhibitory (Vinutha *et al.* 2007), immunostimulant (Dahanukar *et al.* 1990; Thatte 1991; Kapil and Sharma 1997; Diwanay *et al.* 2004; Nair *et al.* 2004; Citarasu *et al.* 2006), antioxidant (Prince and Menon 1999; Singh *et al.* 2006), anti-proliferation (Singh *et al.* 2003), antimicrobial (Samy 2005), anti-ulcer and anti-oxidant (Bafna and Balaraman 2005), antiallergic rhinitis (Badar *et al.* 2005), anti-inflammatory (Sumy *et al.* 2000), antiatherogenic (Mary *et al.* 2003), antimalarial (Najib *et al.* 1999; Bertani *et al.* 2007), antineoplastic (Jagetia *et al.* 1998), antitumour (Mathew and Kuttan 1999), hypoglycemic (Stanely *et al.* 2000; Kar *et al.* 2003), hypolipidaemic (Prince 1998) (**Table 28**).

Phytochemicals: Amritosides A, B, C and D: clerodane furano diterpene glucosides (Maurya *et al.* 2004), arabinogalactan (Chintalwar *et al.* 1999), tinocordifolin (Maurya and Handa 1998), sesquiterpene glucoside (Maurya *et al.* 1997), norditerpene furan glycosides (Gangan *et al.* 1995), (*S*)-coclaurine-*N*-methyltransferase (Loeffler *et al.* 1995), clerodane diterpenoids (Maurya *et al.* 1995), cordioside, a clerodane furano diterpene glucoside (Wazir *et al.* 1995), cordifolisides A, B, C: Norditerpene furan glycosides (Gangan *et al.* 1994) apart from clerodane furano-diterpene lactones (Akhila *et al*. 1991) diterpenoid furanolactone are of pharmaceutical importance (Jampani *et al.* 1986).

Ethnopharmacy: The leaf juice mixed with honey is used to treat gonorrhoea. The whole plant is used to treat piles and ulcerated wounds and for the preparation of medicinal baths for liver disorders. The fresh leaves and stem are used to treat chronic rheumatism. The stem powder is used to treat asthma, burning sensation, leprosy and jaundice (Sumy *et al*. 2000; Parrotta 2001).

Conservation measures: Rapid clonal propagation of *T. cordifolia* using mature nodal explants on MS medium supplemented with 2.32 µM kinetin was developed by Raghu *et al.* (2006). Micropropagation of *T. cordifolia* using nodal explants on MS medium containing 13.94 mM KN were successfully (100% response) established by Gururaj *et al.* (2007).

48. *Urginea nagarjunae* Hemadri & Swahari - Liliaceae

Trade name: Indeterminate.

Threat status: Globally endangered (Jadhav 2001).

Medicinal importance: The dried bulb is used as an anthelmintic and alexiteric, paralysis, bronchitis, asthma, dropsy, rheumatism and the paste of leaves is used for chapped and cracked skin (Jadhav 2001).

Ethnopharmacy: Tribals used the plant tubers in treating rheumatism, corns and wounds and fruits in treating dysentery (Parrotta 2001).

49. *Vanda tessellate* (Roxb.) G. Don - Orchidaceae

Trade name: Ichneumon plant.

Threat status: Indeterminate.

Medicinal importance: The leaf juice is used for the treatment of certain inflammatory conditions. It is also instilled into the ear as a remedy for otitis. The leaves in the form of a paste are applied to the body to bring down fever. The roots are used in rheumatism, nervous problems, bronchitis, dyspepsia and fever. Unani practitioners hold it to be laxative and tonic to the liver. It is also used to treat hiccough, piles and boils on the scalp (Parrotta 2001). This plant root is reported to contain an alkyl perulate and sitosterol-D-glucoside. The dried whole herb also contains long chain alkanes and alkanol sistosterol, resin, saponin, tannins, fatty acids, colouring agents (Sureshkumar *et al.* 2000). Optimization of *in vitro* seed germination, protocorm growth and seedling proliferation of *V. tessellate* was established by Roy and Banerjee (2002).

Ethnopharmacy: Tribals used the plant roots as an ingredient of medicated oils that are used externally for treating diseases of the nervous system and rheumatism and tubers in treating rheumatism, corns and wounds (Sumy *et al.* 2000).

50. *Vitex trifolia* L. - Verbenaceae

Trade name: Not recorded.

Threat status: Indeterminate.

Medicinal use: It is reported to possess antibacterial (Hossain *et al*. 2001) and antipyretic (Ikram *et al.* 1987) properties. Hernandez *et al*. (1999) have reported the biological properties (antiasthma, anticancer, antifeeding and antifungal activities) apart from anti HIV activity (Ikavati *et al.*

Table 28 *Tinospora cordifolia*: Medicinal uses, phytochemistry and ethnopharmacology.

Arabinogalactan polysaccharide, G1-4A, an immunomodulatory polysaccharide modulates macrophage responses and protects mice against lipopolysaccharide induced endotoxic shock.	Desai *et al.* 2007
Acetylcholinesterase inhibitory activity.	Vinutha *et al.* 2007
Induction of caspase-3 activated DNase mediated apoptosis by hexane fraction in Ehrlich ascites tumor (EAT) cells.	Thippeswamy and Salimath 2007
Evaluation of French Guyana traditional antimalarial remedies.	Bertani *et al.* 2007
Influence of selected Indian immunostimulant herbs against *White spot syndrome virus* (WSSV) infection in black tiger shrimp, *Penaeus monodon* with reference to haematological, biochemical and immunological changes.	Citarasu *et al.* 2006
(1,4)-α-D-glucan activated macrophage.	Nair *et al.* 2006
Induces enzymes of carcinogen/drug metabolism and antioxidant system, and inhibits lipid peroxidation in mice.	Singh *et al.* 2006
Effect of alcoholic extract of Ayurvedic herb on the proliferation and myeloid differentiation of bone marrow precursor cells in a tumor-bearing host.	Singh *et al.* 2006
Mechanism-based inhibition of CYP3A4 and CYP2D6 by Indonesian medicinal plants.	Subehan *et al.* 2006
Efficient in treating allergic rhinitis.	Badar *et al.* 2005
Anti-ulcer and anti-oxidant activity of Pepticare, a herbomineral formulation.	Bafna and Balaraman 2005
Solar-biomass hybrid drier for use in traditional medicine.	Prasad *et al.* 2005
Antimicrobial activity of some medicinal plants from India.	Samy *et al.* 2005
Immunoprotection by botanical drugs in cancer chemotherapy.	Diwanay *et al.* 2004
Its polysaccharide exhibited inhibitory effect on experimental metastasis.	Leyon *et al.* 2004a
Cytokine profile (play crucial roles in regulating various aspects of immune responses) of angiogenesis-induced animals.	Leyon *et al.* 2004b
Amritosides A, B, C and D: Clerodane furano diterpene glucosides.	Maurya *et al.* 2004
Reported immune stimulating novel polysaccharides.	Raveendran *et al.* 2004
Free radical generation and lipid peroxidation during oxygen-glucose deprivation in rat hippocampal slices.	Rawal *et al.* 2004
Hypoglycaemic activity in alloxan diabetic rats.	Kar *et al.* 2003
Anti-inflammatory activity.	Li *et al.* 2003a, 2003b
Antiatherogenic effect of Caps HT2, a herbal Ayurvedic medicine formulation.	Mary *et al.* 2003
Medicinal plants of India with anti-diabetic potential.	Grover *et al.* 2002
In vitro antifilarial effect against adult worms of *Brugia malayi*.	Zaridah *et al.* 2001
Traditional Indian anti-diabetic plants attenuate progression of renal damage in streptozotocin-induced diabetic mice.	Grover *et al.* 2001
Anti-hyperglycemic effect in experimental diabetes and their effects on key metabolic enzymes involved in carbohydrate metabolism.	Grover *et al.* 2000
Immunomodulatory activity.	Manjrekar *et al.* 2000
Hypoglycaemic and other related actions in alloxan-induced diabetic rats.	Prince *et al.* 2000
An immunologically active arabinogalactan.	Chintalwar *et al.* 1999
Immunomodulatory and antitumour activities.	Mathew *et al.* 1999
Antimalarial activity.	Rahman *et al.* 1999
Antioxidant activity.	Prince *et al.* 1999
Evaluation of the antineoplastic activity in cultured HeLa cells.	Jagetia *et al.* 1998
Tinocordifolin, a sesquiterpene.	Maurya *et al.* 1998
Hypolipidaemic action of roots in alloxan diabetic rats.	Prince *et al.* 1998
Macrophage functions in ochratoxin A-treated mice.	Dhuley *et al.* 1997
Reported to have immunopotentiating compounds.	Kapil *et al.* 1997
A sesquiterpene glucoside.	Maurya *et al.* 1997
Activity of a crude extract formulation in experimental hepatic amoebiasis and in immunomodulation.	Sohni *et al.* 1996
Norditerpene furan glycosides.	Gangan *et al.* 1995
(*S*)-coclaurine-*N*-methyltransferase.	Loeffler *et al.* 1995
Clerodane diterpenoids.	Maurya *et al.* 1995
The antiamoebic effect of a crude drug formulation against *Entamoeba histolytica in vitro* and *in vivo*.	Sohni *et al.* 1995
Cordifolisides A, B, C: Norditerpene furan glycosides.	Ganga *et al.* 1994
Biosynthesis of the clerodane furano-diterpene lactone skeleton.	Akhila *et al.* 1991
Immunotherapeutic activity.	Thatte *et al.* 1991
Immunotherapeutic activity.	Dahanukar *et al.* 1990
A diterpenoid furanolactone.	Hanuman *et al.* 1986
Cordioside, a clerodane furano diterpene glucoside.	Wazir *et al.* 1995

2001; Woradulayapinij *et al.* 2005).

Phytochemicals: Abietane-type diterpene, named vitetrifolin A, and two labdane-type diterpenes, named vitetrifolins B and C, were isolated from the acetone extract of the fruits along with three known diterpenes, rotundifuran, dihydrosolidagenone and abietatriene 3β-ol. The structures of these compounds were elucidated on the basis of spectroscopic analysis, X-ray crystallographic analysis and chemical evidence (Ono *et al*. 2000).

Ethnopharmacy: The roots are reported to be useful in treating painful inflammations, cough and fevers. Leaves are reported to be useful in conditions of loss of memory, loss of hair, leucoderma and tuberculosis. Flowers are effective in treating fevers and fruits in treating amenorrhoea (Sumy *et al*. 2000).

Conservation measures: The maximum number of shoots (9 shoots per explant) was developed on MS medium supplemented with 5.0 μM BAP using nodal segments. Rooting of shoots was achieved on half-strength MS medium supplemented with 0.5 μM NAA (Hiregoudar *et al.* 2006).

51. *Vitex negundo* L. - Verbenaceae

Trade name: Five-leaved chaste tree.

Threat status: Indeterminate.

Medicinal and phytochemical importance: The plant is mostly used as a fire wood crop (Misra *et al*. 1995). A new flavonoid was isolated from the extract of leaves which is regarded as new flavone glycoside along with five known compounds (Sathiamurthy *et al*. 2007). The leaf extract also exhibited anti-insecticidal property (Nathan *et al*. 2006). In

the ayurvedic system of medicine it is used as a drug of choice to manage pain, inflammation and other related diseases. It contains many polyphenolic compounds, terpenoids, glycosidic iridoids and alkaloids. Since polyphenolic compounds have high antioxidant potential, therefore its reported anti-inflammatory properties could be through the down regulation of the free radical mediated pathway of inflammation (Triwari and Tripathi 2007). Bhargava (1989) reported a flavonoid from seed extract which exhibits anti-androgenic effect. Dharmasri *et al*. (2003) reported oral anti-inflammatory, analgesic and antihistamine properties of mature fresh leaves. Leaves show anti hyperglycemic, antibacterial, antisnake venom, hypoureceamic activities (Samy *et al*. 1998; Alam and Gomes 2003; Villasenor and Lamadrid 2006; Umamaheshwari *et al*. 2007). Gout (characterized by marked hyperuricemia, leading to the deposition of urate monohydrate crystals in joint and kidney, resulting in gouty arthritis and uric acid nephrolithiasis) is one of the most common metabolic disorders that affect humans. Gout is treated either by increasing the excretion of uric acid or by reducing uric acid production. In this context, xanthine oxidase inhibitors (XOI) are desirable due to fewer side effects compared to uricosuric and other anti-inflammatory agents.The methanolic extracts of *Vitex negundo* leaves showed more than 50% xanthine oxidase inhibition (Umamaheswari *et al*. 2007). An ethanolic extract of *V. negundo* resulted in the isolation of another new iridoid glucoside which was characterized as 6′-*p*-hydroxybenzoylmussaenosidic acid (Sehgal *et al*. 1983). Acetyl oleanolic acid, sitosterol and a new furanoeremophilane characterized as 3-formyl-4,5-dimethyl-8-oxo-5*H*-6,7-dihydronaphtho (2,3-*b*) furan have been isolated from the roots (Vishnoi *et al*. 1983). The seeds were the source of a new lignan characterized as 6-hydroxy-4-(4-hydroxy-3-meth-oxyphenyl)3-hydroxymethyl-7-methoxy-3,4-dihydro-2 naphthaldehyde by spectroscopic methods (Chawla *et al*. 1992).

Ethnopharmacy: The stem juice is taken orally with honey to relieve indigestion among the tribal inhabitants of Northern Orissa. The fresh aromatic leaves are reportedly useful for reducing swelling joints due to acute rheumatism and to relieve sprains. Their decoction is used as a bath to relieve body pains and the leaf paste is applied on the body to relieve body ache among the tribals. The dried leaves are used as a tonic and vermifuge. They are sometimes smoked for relief of headache and catarrah. The leaf juice is used to clean infected ulcers and an ointment made from the leaf juice is used as a hair tonic. Among the tribals the powdered young roots are taken into milk to restore fertility and to relieve menstrual disorders. The seeds are considered cooling and are used to treat skin diseases and leprosy. The leaves are also used as a mosquito repellent (Parrotta 2001).

Conservation measures: Optimum shoot multiplication and elongation was achieved when nodal explants were cultured on MS media containing a combination of 1.0 µM BAP and 0.5 µM NAA. Efficient rooting was achieved directly in soilrite when basal portion of the shoots were treated with 500 µM IBA for 10 min which was most effective in inducing roots as 97% of the microshoots produced roots (Ahmad and Anis 2007). Culture of nodal segments on MS medium supplemented with 4.4 µM BAP and 0.53 µM NAA were found to develop fully functional flowers. MS medium supplemented with 4.4 µM BAP and 0.53 µM NAA induced an average of five shoots per node and was the best for axillary bud proliferation. Subsequent cultures enhanced the number of shoots. Full strength MS solid medium with 3.69 µM IBA exhibited the best *in vitro* rooting (Vadawale *et al*. 2006) Maximum number of shoots (8.5 ± 1.195) were developed on MS medium fortified with 6 mg L^{-1} BAP. These multiple shoots were subcultured after three weeks of inoculation for shoot elongation on the same medium augmented with GA_3 (2.0 mg L^{-1}). *In vitro* raised elongated shoots (>7.5 cm) from the cluster were excised and transferred on rooting medium (half-strength MS medium) fortified with 0.5 mg L^{-1} IBA (Sharma *et al*. 2006). Shoot multiplication was induced by different concentrations of TDZ, BAP and 6-furfuryl amino purine separately along with 10% (v/v) coconut water. Green organogenetic callus was obtained by the combined effect of 0.5-2.15 µM TDZ and 1.7 µM IAA along with 1% PVP, and produced the maximum number of shoots when subcultured onto medium containing 2.7 µM TDZ alone. Elongation of *in vitro* shoots was observed in MS medium containing 2.4 µM GA_3 and rooting was induced by the combined effect of 1.71 µM IAA and 1.62 µM NAA (Rani and Nair 2006). In University of Hyderabad Campus, the stem cuttings of *V. trifolia* and *V. negundo* were planted across the edges of the field experimental site and field gene bank as a part of an *ex situ* conservation measure. The growth was often very gregarious and abundant wherein the requirement of water was also very less. These plants were grown initially in pots, circular cemented rings and on the ground. Later they were transferred to a field gene bank (biofence).

52. *Withania somnifera* (L.) Dunal. - Solanaceae

Trade name: Ashwagandha.

Threat status: Indeterminate.

Medicinal uses: The root extract of *W. somnifera* (**Fig. 14**) is consumed as a dietary supplement around the world. Leaves, stem bark, root bark, seeds and whole plant extracts are used for treatment of malaria (Muregi *et al*. 2007). Me-

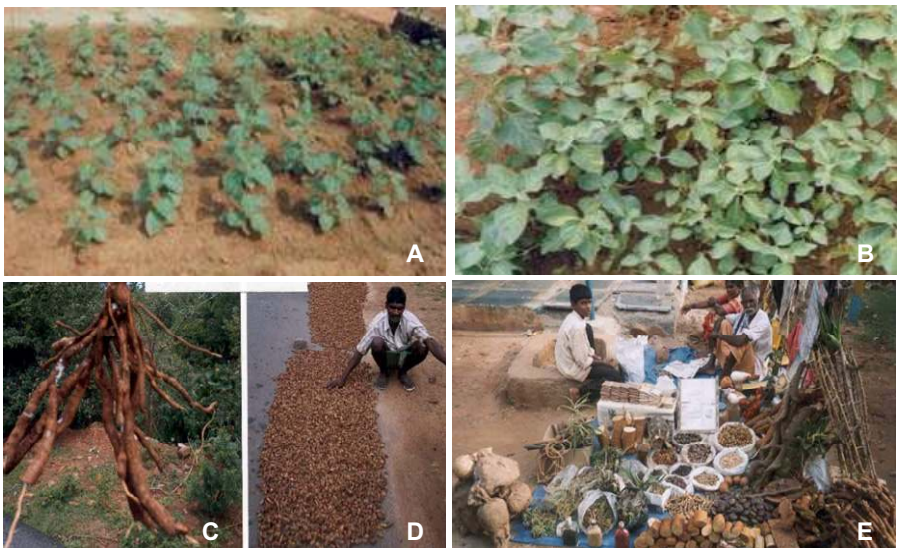

Fig. 14 Selected MAP germplasm in field experimental site. (**A, B**) *Withania somnifera* in cultivation; (**C, D**) *Decalepis hamiltonii* roots; (**E**) Village doctor displaying a wide range of herbal raw materials for consumers.

Table 29 *Withania somnifera*: Ethnopharmacological applications.

Protective effect of on collagen glycation and cross-linking.	Babu *et al*. 2007
Triadimefon induced salt stress tolerance and its relationship to antioxidant defense system.	Jaleel *et al*. 2007
Anti-inflammatory and cytotoxic activity.	Kaileh *et al*. 2007
Selective reactivity of 2-mercaptoethanol with 5β,6β-epoxide in steroids.	Misra *et al*. 2007
Indian ginseng in neuro-psychopharmacology and biological psychiatry.	Kulkarni *et al*. 2007
Purification and physico-kinetic characterization of 3β-hydroxy specific sterol glucosyltransferase and its stress response.	Madina *et al*. 2007a
Purification and characterization of a novel glucosyltransferase specific to 27β-hydroxy steroidal lactones its role in stress responses.	Madina *et al*. 2007b
Root extract and its major constituent withanolide-A elicit humoral and cell-mediated immune responses by up regulation of T helper (Th) lymphocyte (Th1)-dominant polarization in BALB/c mice.	Malik *et al*. 2007
Antimalarial activity of methanolic extracts from plants used in Kenyan ethnomedicine and their interactions with chloroquine (CQ) against a CQ-tolerant rodent parasite, in mice.	Muregi *et al*. 2007
Withanolide induces apoptosis in leukemia cells (HL-60) via mitochondria mediated cytochrome c release and caspase activation Withanolides from leaves are reported to have an antiproliferative activity and have inhibitory effect on the cyclooxygenase-2 (COX-2) enzyme.	Senthil *et al*. 2007
Molecular cloning and characterization of one member of 3β-hydroxy sterol glucosyltransferase gene family.	Sharma *et al*. 2007
Screening of selected Indian medicinal plants for acetylcholinesterase inhibitory activity	Vinutha *et al*. 2007
Hypocholesteremic and antioxidant effects in hypercholesteremic rats.	Visavadiya *et al*. 2007
Selective Th1 up-regulating activity of aqueous extract in an experimental system using flow cytometry.	Bani *et al*. 2006
Phytochemical and genetic analysis in selected chemotypes.	Dhar *et al*. 2006
Effects of temperature, pre-chilling and light on seed germination.	Kambizi *et al*. 2006
Augmentation and proliferation of T lymphocytes and Th-1 cytokines in stressed mice.	Khan *et al*. 2006
Anti-plasmodial activity and toxicity of plant extract in traditional malaria therapy Kenya.	Kirira *et al*. 2006
Purification of a post-synaptic neurotoxic phospholipase A2 from *Naja naja* venom and its inhibition by a glycoprotein.	Machiah *et al*. 2006
Its glycoproteininhibits hyaluronidase activity of snake venoms.	Machiah *et al*. 2006
Enhancement of antitumor effect of paclitaxel in combination with its immunomodulatory principles on benzo(a)pyrene induced experimental lung cancer.	Senthilnathan *et al*. 2006a
Modulation of TCA cycle enzymes and electron transport chain systems in experimental lung cancer.	Senthilnathan *et al*. 2006b
Immunomodulatory role of root powder on experimental induced inflammation: An *in vivo* and *in vitro* study.	Rasool and Varalakshmi 2006
Regeneration of plants from alginate-encapsulated shoot tips.	Singh *et al*. 2006
Cytotoxicity of plants used in traditional medicine in Yemen.	Al-Fatimi *et al*. 2005
Withanolides, a new class of natural cholinesterase inhibitors with calcium antagonistic properties.	Choudhary *et al.* 2005
Purification and characterization of peroxidases and their ability to oxidize IAA.	Johri *et al*. 2005
Antibacterial efficacy against experimental murine salmonellosis.	Owais *et al*. 2005
Adaptogenic activity.	Singh *et al*. 2005
The *in vitro* antibacterial/synergistic activities.	Arora *et al*. 2004
Immunoprotection in cancer chemotherapy.	Diwanay *et al*. 2004
Immune response modulation to DPT (Diphtheria, Pertussis, Tetanus) vaccine. Vaccine by aqueous extract.	Gautam *et al.* 2004.
Fruits contain potent lipid peroxidation inhibitors.	Jayaprakasam *et al*. 2004
Evaluation of the anti-proliferative and anti-oxidative activities of leaf extract.	Kaur *et al*. 2004
Quantitative HPLC analysis of withanolides.	Ganzera *et al*. 2003
Cyclooxygenase-2 enzyme inhibitory withanolides from leaves.	Jayaprakasam and Nair 2003
Growth inhibition of human tumor cell lines by withanolides from leaves.	Jayaprakasam *et al*. 2003
Natural phospholipase A2 myotoxin inhibitor proteins from snakes, mammals and plants.	Lizano *et al*. 2003
Purification and characterization of a glycoprotein inhibitor of toxic phospholipase.	Deepa *et al*. 2002
The effect of aqueous extracts on testicular development in immature Wistar rats together with *Cynomorium coccineum*.	Abdel-Magied 2001
Calystegine distribution in some solanaceous species.	Bekkouche *et al*. 2001
Structures of withanosides I, II, III, IV, V, VI, and VII, new withanolide glycosides, from the roots - inhibitory activity for tachyphylaxis to clonidine in isolated guinea-pig ileum.	Matsuda *et al*. 2001
Antiradicals and DNA cleavage protectors.	Russo *et al*. 2001
Adaptogenic activity of a glyco-peptido-lipid fraction from the alcoholic extract of *Trichopus zeylanicus* Gaertn.	Singh *et al*. 2001
Immunomodulatory activity.	Land and Kuttan 2000
Adaptogenic and cardioprotective action in rats and frogs.	Dhuley 2000
Association of L-DOPA (3,4-dihydroxy-L-phenylalanine) with recovery in Parkinson's disease.	Nagashayana *et al*. 2000
Antioxidant activity.	Scartezzini and Speroni 2000
Immunomodulatory activity.	Agarwal *et al*. 1999
Plays a role in regulation of circulating thyroid hormone concentrations in female mice.	Panda *et al*. 1999
Withanolide synthesis in cultures transformed with *Agrobacterium tumefaciens*.	Ray and Jha 1999
Antistressor effect of *W. somnifera*.	Archana and Namasivayam 1998
Lipid peroxidation in stress-induced animals.	Dhuley 1998
Withanolides from the stem bark of *W. somnifera*.	Ali *et al*. 1997
Immunomodulatory function.	Ziauddin *et al*. 1996
In vivo growth inhibitory and radiosensitizing function of withaferin A on mouse Ehrlich ascites carcinoma.	Devi *et al*. 1995
A comparative pharmacological investigation of Ashwagandha and Ginseng.	Grandhi *et al*. 1994
Treatment of osteoarthritis with a herbomineral formulation: a double-blind, placebo-controlled, cross-over study.	Kulkarni *et al*. 1991
Anti-inflammatory activity.	Al-Hindawi *et al*. 1989
Glycosaminoglycan synthesis in carrageenin-induced air pouch granuloma.	Begum and Sadique 1987
In vitro absorption of [^{14}C]leucine during inflammation and the effect of antiinflammatory drugs in the jejunum of rats.	Somasundaram *et al*. 1983
A chemotaxonomic study.	Abraham *et al*. 1968

Table 30 *Withania somnifera*: Phytochemical wealth (Scartezzini and Speroni 2000).

Whole plant: 1,3,20-trihydroxy-5, 24-withadienolide; 14,20R, 27-trihydroxy-1-oxo-3, 5,24-withatrienolide; 14-hydroxywithanolide-D; 17-hydroxywithanolide-D; 24-methylcholesta-5, 24-dien-3β-ol; 27-hydroxywithanolide-D; 5,20α-(R)-dihydroxy-6α , 7α-epoxy-1-oxo-(5α)-witha-2, 24-dienolide; 5,24-stigmastadien-3-ol; pseudowithanin; scopoletin; somniferianine; somniferine; somnine; somnisol; somnitol; steroidal lactone I useful to clarify the withanolides G, H, I, J, K, U structures with 14α hydroxy group; tropine; withanine; withanolide E(20R,22R)14α,20-dihydroxy-1-oxowitha-2,5,16,24-tetraenolid); withanolides I, II, III, IV.

Leaves: 27-desoxy-14 α-hydroxywithaferin A; α-alanine; chlorogenic acid; flavonoids; glucose; inorganic salts; glutamic acid; glycine; cystine; proline, somnirol; tryptophan; withaferin (2,3-dihydro-3-methoxy withaferin A); withaferin A isomer (27-deoxy-14-hydroxywithaferin A); withaferin A(4β,27-dihydroxy-1-oxo-5β,6β-epoxy-22-witha-2,24-dienolide); withananine; withanic acid; withanolide D (5β,6β-epoxy-4β,20-dihydro-1-oxowitha-2,24-dienolide); withanolide E, U, F, I, K (17,20-dihydroxy-1-oxo-20S-22R- 3,5,24-trienolide); withanolide L (17,20,dihydroxy-1-oxo-20S,22R-witha-2,5,14,24-tetraenolide); withanolide M (17,20-dihydroxy-1-oxo,14,15aepoxy-20S-22R- witha-2,5,24-trienolide); withanolide G (20-hydroxy-1-oxo-20R,22R-witha-2,5,24-trienolide); withanolide H (20,27-dihydroxy-1-oxo-20R,22R-witha-2,5,24-trienolide); withanolide J (17,20-dihydroxy-1-oxo-20S,22R-witha-2,5,24-trienolide); withanolide N; withanolide O; withanone (5α,17α-dihydroxy-1-oxo-6α,7α-epoxywitha-2,24-dienolide)

Roots: 3-tropyltigloate, 3 α-tigloyoxytropane, anaferine, anahygrine, β-sitosterol, choline, cuscohygrine, dulcitol, hentriacontane, ipuranol, isopelletierine, nicotine, pseudotropine, somniferinine, visamine, withaferin-a, withaniol, withasomine, anaferine (bis(2-piperidylmethyl)ketone), isopelletierine, tropine, pseudotropine, 3-tigloyloxytropane, cuscohygrine, DL-isopelletierine, anahygrine, hygrine, meso-anaferine, *cis*-28 steroid lactone characterizedas 5,20 α -dihydroxy-6 α,7 α-epoxy-1-oxo-5 α witha-2,24-dienolide, choline, saccharose (0.1%); β-sitosterol (0.02%); somniferine; somniferinine; withanine; withananine; nicotine; ipuranol; hentriacontane; fatty acids; essential oil; scopoletin; withanolides; withaniol; withananine; pseudowithanine; choline; withasomnine.

Fruit: chamase, cysteine, cystine hydroxyproline.

Seeds: withanolide WS-1, withaferin A and dihydrowithaferin A2.

thanolic leaf extract and its active component, withanolide was used to treat leucoderma and air pouch granuloma, gouty arthritis, analgesic and fever (Hazeenazbegum and Sadique 2004; Rasool and Varalakshimi 2006; Senthil *et al*. 2007). The standardized root extract which contains Withanolide A finds useful applications against the intracellular pathogens and in the management of immune suppressed diseases (Malik *et al*. 2007). Bhattacharya *et al.* (2001) reported the antioxidant activity of glycowithanolides. Anti tumour, antidiabetic and immunomodulatory activities were reported by Parihar *et al.* (2004) and Senthilnathan *et al.* (2006). The activity of ethanolic extract of *Withania* is comparable to metformin, a known antiglycating agent i.e., it could have therapeutic role in the prevention of glycation induced pathogenesis in diabetes mellitus and aging (Babu *et al*. 2007). It also exhibits cytotoxic (Al-Fatima *et al*. 2005), α-amylase inhibitory (Prashanth *et al*. 2001), adaptogenic (Ganzera *et al.* 2003), antibacterial/synergistic (Arora *et al*. 2004), immunostimulation (Gautam *et al*. 2004), adaptogenic, cardiotropic, cardioprotective and anticoagulant (Dhuley 2000), anthelmintics (Jabbar *et al*. 2006), anticarcinogenic (Christina *et al*. 2004), anti-granuloma (Al-Hindawi *et al*. 1992), anti-inflammatory (Al-Hindawi *et al*. 1989), anti-plasmodial (Kirira *et al*. 2006), antistressor (Archana and Namasivayam 1998), anti-proliferative (Mathur *et al*. 2006), anticataract (Halder *et al*. 2003), antioxidant (Scartezzini and Speroni 2000), anti-tumoral (Kaileh *et al*. 2007), acetylcholinesterase (AChE) inhibitory (Vinutha *et al*. 2007), immunomodulatory (Ziauddin *et al*. 1996; Agarwal *et al*. 1999; Davis and Kuttan 2000; Diwanay *et al*. 2004) activities. *W. somnifera*, also known as ashwagandha, Indian ginseng and winter cherry, has been an important herb in the Ayurvedic and indigenous medical systems for over 3000 years. It is widely used as a general tonic to increase energy, improve overall health and longevity. Studies revealed that *W. somnifera* possesses anti-inflammatory, antitumor, antistress, antioxidant, immunomodulatory, hematopoetic and rejuvenating properties. *Withania* benefits the endocrine and cardiopulmonary systems and the CNS. Clinical trials and animal research support the use of *Withania* for anxiety, cognitive and neurological disorders, inflammation, and Parkinson's disease (**Table 29**). *Withania* holds a portion of importance similar to ginseng in China having a rejuvenating effect on the body. Preliminary studies have found that various constituents of *Withania* exhibit a variety of therapeutic effects with little or no associated toxicity (**Table 29**). The roots are the main portion of the plant used therapeutically. The major biochemical constituents of *Withania* root are steroidal alkaloids and steroidal lactones in a class of constituents called withanolides. To date, up to 19 withanolide derivatives have been isolated from *Withania* roots (**Table 30**). *Withania*'s pharmacological activity has been attributed to two main withanolides, withaferin A and withanolide D (**Tables 29, 30**). Its active components were shown to scavenge free radicals and inhibit lipid peroxidation (**Table 29**). The chemopreventive activity could be due in part to the antioxidant/free radical scavenging activity of the extract (**Table 29**).

Phytochemicals: Withaferin A, sitoindoside IX, 4-(1-hydroxy-2,2-dimethylcyclpropanone)-2,3-dihydrowithaferin A, 2,3-dihydrowithaferin A,24,25-dihydro-27-desoxywithaferin A, physagulin D (1→6)-β-D-glucopyranosyl-(1→4)-β-D-glucopyranoside, 27-*O*-β-D-glucopyranosylphysagulin D, physagulin D, withanoside IV, 27-*O*-β-D-glucopyranosyl-viscosalactone B,4,16-dihydroxy-5β,6β-epoxyphysagulin D, viscosalactone B (Jayaprakasam *et al*. 2003), withanosides I-VII, withaferin A, 5α,20αF(R)-dihydroxy-6α,7α-epoxy-1-oxowitha-2,24-dienolide, and coagulin Q (Matsuda *et al*. 2001), withasomnilide, withasomniferanolide, somniferanolide, somniferawithanolide and somniwithanolide (Ali *et al*. 1997) (**Table 30**).

Ethnopharmacy: Among the tribals the roots are used to treat general debility, insomnia and painful urination. The roots as well as bruised leaves are used externally to treat ulcers, painful swellings, carbuncles and scabies. The alkaloids present in the roots produce relaxant and anti spasmodic effects on intestinal, uterine, bronchial and blood vascular muscles. The leaves are anthelmintic and bitter and their infusion is used to relieve fever. The bruised leaves are sometimes applied to relieve sore eyes (Parrotta 2001).

Conservation measures: When leaf explants were cultured on MS basal medium supplemented with IAA (7.99 μM) and BAP (4.4 μM) multiple shoots were formed. The number of shoots formed per explant was also maximum at 7.99 μM IAA. The frequency of explants forming shoot buds decreased at 11.42 μM IAA. Rooting was observed on MS medium supplemented with 0.044 μM BAP (Kulkarni *et al.* 1996). The best gel composition was achieved using 3% sodium alginate and 75 mM $CaCl_2 \cdot 2H_2O$ using shoot tips for encapsulation. The maximum percentage response (87%) for conversion of encapsulated shoot tips into plantlets was achieved on MS medium supplemented with 0.5 mg L^{-1} IBA after 5 weeks of culture. The conversion of encapsulated shoot tips into plantlets also occurred when calcium alginate beads having entrapped propagules were directly sown in autoclaved soilrite moistened with ¼-MS salts (Singh *et al.* 2006). The germplasm in the form of seeds, seedlings, plants was collected and maintained in the field gene bank as a part of an *ex situ* conservation measure at the University of Hyderabad campus.

53. *Zanthoxylum alatum* Roxb. - Rutaceae

Trade name: None.

Threat status: Indeterminate.

Medicinal importance: The plant extract exhibit anti fungal and insect repellent activity (Dube *et al*. 1990). More specifically it is reported to act as a leech repellent (North *et al*. 1993)

Phytochemicals: Linalool, limonene, β-phellandrene, (*Z*)-methylcinnamate (Jain *et al*. 2001), *cis*-10-octadecenoic acid (Venkatachalam *et al*. 1996), 1,8-cineole, linalool, undecan-2-one (Weyerstahl *et al*. 1999), zanthoxyl flavone, geranioloxyalatum flavone (Ramidi and Ali 1999), (*E*)-methyl cinnamate, ethyl 9-hexadecenoate, ethyl hexadecanoate (Ramidi *et al*. 1998).

Ethnopharmacy: The essential oil obtained from the fruits of *Z. alatum* shows anti fungal, anthelmintic and insect repellent activities (Dube 1990). The structure of tambuletin, present in seeds of zanthoxylum species has been confirmed as the 8-glucoside of gossypetin 7,4′-dimethyl ether. The seeds *of Z. alatum* on hydrodistillation, gave 1.5% of oil (v/w). Linalool (71%), limonene (8.2%), β-phellandrene (5.7%) and (*Z*)-methylcinnamate (4.9%) were the major components. It is suggested that the seeds can be used as a commercial source for the isolation of linalool (Jain *et al.* 2001). Bisht and Snehlata (2007) developed the callusing response and direct *in vitro* regeneration of nodal explants of *Z. alatum*.

IMPEDIMENTS TO CONSERVATION, UTILIZATION AND COMMERCIALIZATION

Conservation issues: Conservation of the plant resources is a subject of national and international concern because we do not know what we will need in the future. Proper conservation measures should be followed in order to protect the Redlisted plant genetic resources exist (**Fig. 15**). The key to overall success will lie in the development of an integrated approach for conservation (= Collection and characterization). The two commonly used strategies for conserving plant genetic resources are *in situ* conservation, which allows evolution to continue within the area of natural occurrence and *ex situ* conservation, which provides higher degree of protection to germplasm compared to *in situ* conservation by conserving outside the natural habitats.

Information on traditional knowledge, ethnophamacology, cultivation, utilization, biotechnology and conservation, opportunities and hype for MAPs from Deccan ecoregion have been mentioned *supra vide*. However, this would be a reality only when the impediments are resolved. There is much scope to investigate several of these issues, with challenging limitations (**Fig. 16**) (Canter *et al*. 2005).

a) Decline in species richness (over exploitation and natural catastrophies like fire, flooding, tsunami etc.).
b) Deletion of plant systematics in higher education curriculum.
c) Agro-technology has beeen standardized for very a few MAPs such as *Artemisia annua*, *Cymbopogon winterianus* (citronella), *C. martinii* (palmarosa), *C. flexuosus* (lemongrass), *Cassia angustifolia* (senna), *Chrysanthemum cineraefolium* (pyrethrum), *Mentha arvensis* (menthol mint), *M. citrata* (bergamot mint), *M. piperata* (peppermint), *M. spicata* (spearmint), *M. cardiaca* (Scotch spear mint), *Ocimum sanctum* (tulsi), *Pelargonium graveolens* (geranium), *Phyllanthus amarus* (Bhumi amlai), *Vetiveria zizanioides* (vetiver) and *Withania somnifera* (Ashwagandha) (e.g. Teixeira da Silva 2003, 2004; Teixeira da Silva *et al*. 2005; Teixeira da Silva 2006).
d) Lack of cultivation practices and agro-technology for

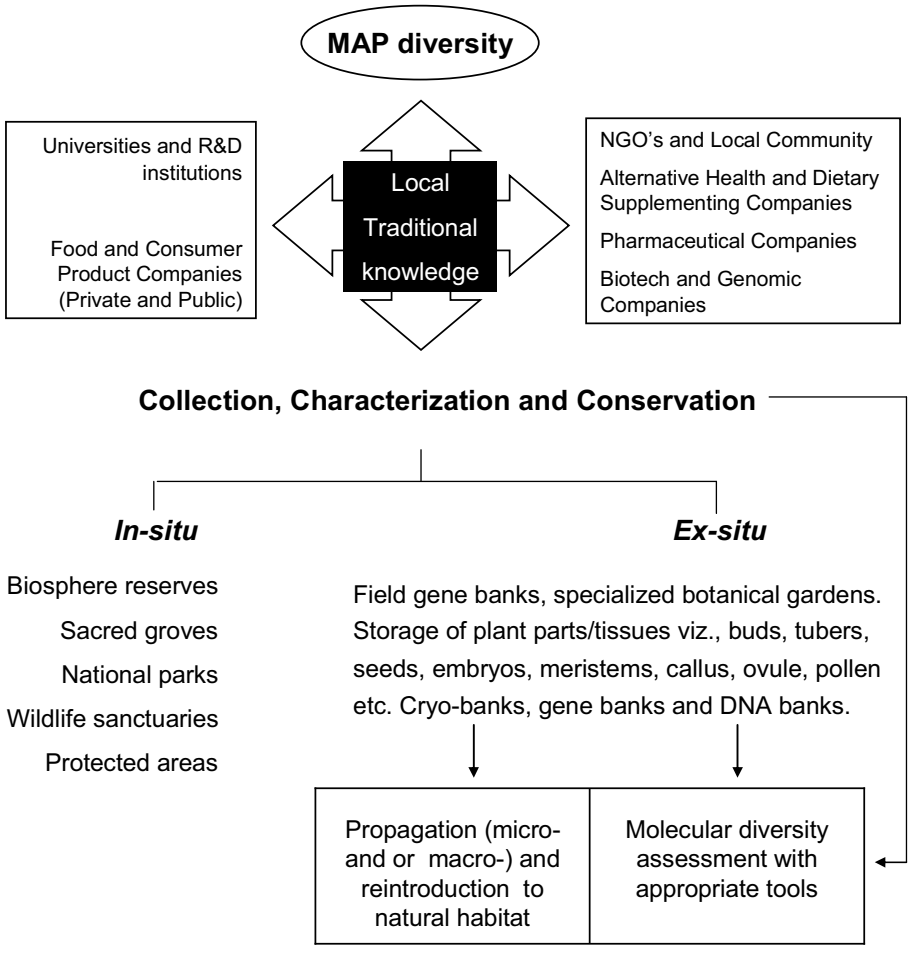

Fig. 15 Players in an emerging health and wellness market. Strategies for advancing cultivation, utilization and conservation of healing plants involving various partners.

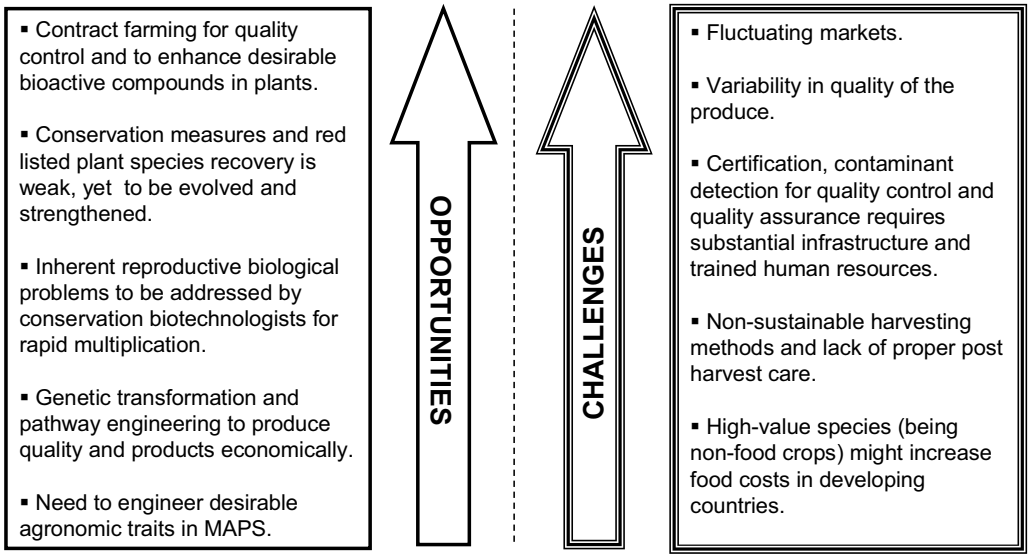

Fig. 16 Medicinal plant cultivation, utilization, conservation and biotechnology - issues, opportunities and challenges.

majority of MAPs (except for a few stated above).

e) Insufficient tools for preserving traditional knowledge.
f) Very little or no financial support for long term conservation biological research.
g) Imbalance in demand and supply chain (indigenous vs. export) as the world market for herbal drugs and health foods is tremendously increasing.
h) Herbal products are often contaminanted with organics and inorganic (Prasad 2006). Hence product standardization and certification is a must. Very a few qualified labs have infrastructure for sophisticated facilities for quality control and quality assurance.
i) Yield of active principles would vary from geographic regions for e.g. Indian *Centella asiatica* 1 ton is priced in international market at a price of about US$ 600 while the same product from Madagascar attracts a price of US$ 3600.
j) Genetic diversity assessment-chemoprofile-yield correlation is not known for many MAPs.

A comprehensive joint forest management sustainable for collection and harvesting of medicinal plants, development of post-harvest technology for retaining the active principles needs critical investigation (Dixit *et al*. 2005).

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