CHAPTER - 1

INTRODUCTION
INTRODUCTION

The global context briefly suggests several tremendous opportunities for India, a country unrivaled in terms of diversity of systems and practices, in addition to being major storehouse of biological diversity, with 2 of the 14-mega biodiversity areas of the world located within its borders. The global market would appear to be more receptive than ever to the mounting of a concentrated Indian effort at supplying it with medical materials and know-how. Such an effort would also appear to be increasingly remunerative for the country. India is of course already an active participant in the global medicinal plants market having been for some time the world’s largest supplier of raw materials (though an insignificant supplier of finished products). Moreover, medicinal plants are one of the most important components of the non-wood forest products sector, which supplies over 80% of India’s net forest annual export earnings.

The agro climatic conditions of the country provide an ideal habitat for natural growth of variety of plants and herbs. Plants were the first medicines, and even as modern humans have developed sophisticated pharmaceutical chemicals to treat illness, medicinal plants remain an important tool for treating illness in most cultures.

Human beings have been utilizing plants for basic preventive and curative health care. According to a survey carried out by WHO, 80% population of developing countries still rely on traditional medicines, mostly plant based drugs (Anonymous, 1998). A rich heritage of knowledge on preventive and curative medicines was even available in Atharva Veda, Charkha, Sushruta etc.
Moreover 25,000 effective plant based formulations are available under indigenous medicine. Over one and a half million practitioners of Indian system of Medicine use medicinal plants in preventive, promotive and curative applications. Since the dawn of history man has been in search of ways to find cure and relief from mental and physical illness for ulcers, inflammation, anaemia, scabies, leucoderma, epilepsy and asthma. The plant is also reported to show sedative, hyperthyroidism, vasoconstrictor, antiinflammatory and gastrointestinal disorder.

Antimicrobial resistance among key microbial pathogens continues to grow at an alarming rate.

**Description:**

*Bacopa monnieri* belongs to genus of erect or spreading herbs, commonly growing in marshy places throughout India, ascending to an altitude of 1320 m.

Plants produces highly bioactive molecules that allow them to interact with other organisms in their environment. These bioactive compounds are important in defense mechanism and contribute to the resistance to diseases. Many investigators evaluated the bioactivity of plant extracts and the constituents against the serious infectious organisms.

A small creeping, glabrous, succulent herb, rooting at nodes, stem soft obtuse – angular, branches ascending; leaves short petiolate, oblong-cuneate to obovate, 0.6 – 2.5 cm X 3-9 glabrous, up to 5 mm long. Dried crude drug is characterized by mild and hay like odour and very bitter taste. Dried, whole herb or herb without roots or only leaves and tender
stem portions are available as crude drug. The dried crude drug is yellowish in colour with majority of leaves.

**Common names:**
Sanskrit: Brahmi, Nira-brahmi; Hindi: Brahmi; English: Brahmi-sak; Bengali: Jalanimba; Kannada: Nirubrahmi; Malyalam, Marathi and Tamil: Neer brahmi; Telugu: Sambrani chettu; Marathi: Jalnaveri

**Parts used:**
The entire plant constitutes the well-known drug Brahmi.

The reputation of India's ancient wisdom probably needs to be protected by tighter rules. There is a need to collate all the available information regarding medicinal plants development in the country in order to obtain a comprehensive overview, which will provide the necessary insight for coordinated and effective action. Such an overview could form the basis of a renewed development of India's medicinal plants sector, and a strategic exploitation of her comparative advantage in the global market on a sustainable and equitable basis.

**What is Bacopa Monniera?**

Bacopa Monniera is a small, creeping herb with light purple flowers. It grows prolifically in wet soil, shallow water and marshes in India and the Tropics. The plant is known as brahmi in India, ‘ae’ae in Hawai‘i, and otomeazene in Japan. For centuries it has been used as a 'brain tonic' to enhance memory and concentration as well as providing positive benefits for sufferers of epilepsy and anxiety. For over a thousand years it has
played an important part in the tradition of Ayurveda, a system of Indian folk medicine. Western researchers have focused on Bacopa's cognitive benefits – specially its ability to improve memory, learning and concentration.

The active constituents that have been identified in Bacopa monniera include the alkaloids brahmine and herpestine, saponins, d-mannitol and hersaponin, acid A, monnierin, betulic acid, stigmasterol, beta-sitosterol. All of these are believed to be responsible for the pharmacological benefits of bacopa. Bacosides A and B.5 are the compounds that researchers believe are responsible for it's cognitive effects (Chatterji N, Rastogi RP, Dhar ML. Chemical examination of Bacopa monniera Wettst. Part I: isolation of chemical constituents. Indian J Chem 1963; 1:212).

Compound, which is, responsible for the memory enhancing is antiterpenoid saponin called ‘Bacosides’. Bacosides enhance the efficiency of transmission of nerve impulse there by strengthening memory and cognition. It is also used as a laxative and curative of illness. Although synthetic organic compounds have contributed in pharmaceutical applications, satisfactory therapy is available only for about one third of all human ailments known at present and several diseases like cancer; AIDS, autoimmune disease continue to evade resasonable solution. The main reason behind the revival of interest in plant based Ayurvedic drugs in recent years in the developed nations and developing countries is the side effects and high rising prices of the Allopathic medicines. Herbal remedies have attained popularity among the common people, due to increasing awareness of personal health maintenance through natural products. The developed nations are also looking for eco-friendly means for treatment of various diseases through plant source.
Global and National Scenario:-

The Ministry of Environment and Forest (MOEF), Govt. of India, has identified and documented approximately 9500 plants species, which have got an important role in pharmaceutical industry, which are available in India.

About 25% of modern medicines either consist of plant or plant based derivatives. As estimated by the Export Import Bank, (Exim Bank) the international market of medicinal plants related trade is to tune of US $ 60 billion per year having a growth rate of 7% per annum and annual exports of these plants is valued at Rs. 1200 million (Jose et al, 2001). According to one account, in 1992, at least 74 species of medicinal plants were being commercially traded in the global market; the number has now been significantly increased. In addition to these major species, hundreds of others are bought and sold in lesser quantities across national boundaries, sometimes illegally. A comparison of the volumes of traded materials with those of the previous decade also provides dramatic evidence of the market’s growth. Also in 1990, more than 2000 companies in Europe alone were marketing herbal medicinals, the so-called “nutraceuticals” sector-consisting of herbal medicines, which are dubbed food or dietary supplements in order to pass Food & Drug Administration criteria more easily- is now estimated to be valued at USD 27 billion. Herbal demand is increasing progressively with increase in number of star hotels and multinational establishing consumers oriented cosmetic and pharmaceutical units.
Herbal medicines also found market as nutraceuticals (health food) whose current market is estimated at about $80-250 billion in USA and also in Europe. One in four prescriptions filled in a country like the United States is either a synthesized form or derived from plant materials. In the United States, the number of people using herbal medicines has increased from 2.5 per cent in 1990 to 30 per cent in 2000. In India over 7,500 plant species are estimated to be used by 4,635 communities for human and veterinary purposes. About 33% plant species are trees while about 52% are shrubs and herbs. About 1500 plants species are used for ethical and classical formulations and home remedies based on Indian System of Medicines (ISM) such as Ayurveda, Siddha and Unani. It is estimated that Indian consumption alone of these herbs (188 tonnes) is used for culinary purposes and about 12 tonnes are consumed for medicinal and cosmetic preparations. A macro analysis of the distribution of the medicinal plants shows that around 70% of India’s medicinal plants are found in the tropical and subtropical forests and less than 30% are found in temperate and high altitude forests (Jose et al, 2001).

While over 800 species are consumed by industry, less than 20 species of plants are under commercial cultivation. A report prepared by the Planning Commission’s task force for medicinal plants, lists 25 most used plants in ISM. The foreign exchange being earned by India from exports of medicinal and aromatic plants is estimated to be over US $3000 million per annum. The IUCN report for the year 2000 revealed that India ranked fifth in case of threatened plant species and birds. The herbal drugs industry in India is estimated at Rs 2,300 crore, with a 15% annual growth rate. It covers 5,000 companies. The global ayurvedic products market is reportedly worth $14.2 billion (Indian Express, P -11, May 29, 2005). The growing demand of herbal products has tripled the exports from India.
during the last decade and is expected to increase even more in the years to come. Planning Commission Task force targeted exports of herbal products of Rs. 3000 crore by the year 2005 and Rs. 10,000 crore by the year 2010 (Jose et al, 2001).

**Constraints:-**

The major challenges today before our country is to maintain medicinal plant harvest and trade within sustainable levels. Our destructive activities can no longer be denied, but we also depend crucially on the continuation of our economic activities. More than 90% of plant species used by industry are however collected from the wild source of which 70% involves unorganized harvesting.

The rate of extinction of medicinally important plant species is further accelerated by habitat degradation, illelegal trade practices, loss of regeneration potential of degraded forests, policies and regulations. This factor poses a serious threat to the genetic stock and the biodiversity of medicinal plants. The IUCN Red list of threatened plants published by world Conservation Union includes 33,798 species, of which 380 are extinct in the wild, 371 may be extinct, 6,522 are endangered and the remainders are vulnerable or rare. The programme for the development of medicinal and aromatic plants had been continued during Ninth five year plan with an outlay of Rs, 14.50 crore. The wild growing population of these species is fastly reducing particularly in the known habitats and their substitutes and allies have appeared in the market.

The only way to arrest further loss of medicinal plant species and ensure survival of these centuries-old practices of healing would be to encourage sustainable harvesting of plants from the wild source, their replanting in
wild and simultaneously promoting their cultivation on a large scale. Policy and use regulation is one of the most sensitive aspects of developing and using plant based medicines and health products. This means that use must be sustainable and the harvesting and gathering of medicinal plants should be very strictly regulated. Indiscriminate harvesting will lead to the extinction of natural populations, which are still the only source of bioresources. Already, world markets experience wild fluctuations in the price of herbals. Such fluctuations usually come in cycle of six to nine years since the availability of many wild plants goes from oversupply to scarcity very quickly and then stabilizes again.

These swings reflect the stages when the plants are over harvested, are therefore in short supply and command a high price. At this time natural populations are under extreme stress and some are threatened with possible extinction. This price swing would be a good indicator for the government to gauge the threat to distinct plant types by overexploitation and could help to identify the habitats that must be put under strict regulation to foster conservation. National Medicinal Plant Board (NMPB), Govt. of India has currently short-listed some of the important plant species, which requires immediate attention. Some of them are: Amla, Aswagandha, Brahmi, Giloe, Guggal, Kalmegha, Kuth, Senna, Shatavari. Technology, Information, Forecasting, and Assessment Council (TIFAC, DST, GOI) has also recommended 45 medicinal plant species and specifically recommended 7 plants for immediate attention during 2001 – 05.
They are as follows:-

1. *Aloe vera* (Ghrita Kumari),
2. *Bacopa monnieri* (Brahmi)
3. *Centella asiatica* (Mandukparni, Gotukola),
4. *Rauwolfia serpentina* (Sarpagandha),
5. *Catharanthus roseus* (Periwinkle),
6. *Taxus bacata* / *T. Wallichiana* (Himalayan Yew), and
7. *Artemisia annua*.

Finally, there are significant challenges associated with ensuring the safety, quality and efficacy of plant based medicinal content, contamination with abiotic and biotic factors, adulteration with misidentified plant species, efficiency of manufacturing processes and product handling. The major constraints in the development of medicinal plants being experienced by the farmers are non availability of quality planting materials of improved varieties, lack of development and extension support in the cultivation and processing, and unorganized marketing. The need of the hour is to replan India’s participation in the expanding global market, in light of the interests of all the stakeholders who are affected and who play a role in this sector. But quack theories of Ayurveda are being deployed.

**Major uses:**

It is astringent, bitter and cooling, and is reported to improve the intellect. It is used in the indigenous systems of medicine for the treatment of asthma, hoarseness, cough, insanity, epilepsy and as a potent nerve tonic, cardio tonic and diuretic. In Ayurveda, plant is used for dermatitis, anaemia and diabetes. It is also used in boils.
GENERAL INTRODUCTION OF *Bacopa monnieri*

**Production**
No figures for its production for cultivated sources are available. From the wild sources the total annual production is about 3000 tons mainly from the states of Tamil Nadu and West Bengal.

**Domestic**
The annual demand of brahmi was estimated to be about 3800 tons.

**Consumption**
During 2001 – 2002 and keeping in view the 20% annual growth in its demand, it is likely to be more than 6600 tons during 2004-2005.

**Average price**
Brahmi has a good market especially for its "Brahmi Oil" due to its high medicinal value. Rate of dried drug in retail market varies from Rs. 20-25./ Kg. However, 40% saponin extract of *Bacopa monnieri* (Brahmi) of Indian origin is sold in the retail international market at 40 US$ per 100g.

**Plant material**
Collected from wild and also being cultivated at wet marshy localities. The majority of crude drug available in the Indian market is claimed to be from the cultivated sources. However, while procuring material from drug dealers, one can not be sure of the actual sources of the material as the wild collection by the local people are also physically similar to the cultivated material. The plant grows well throughout India at wet marshy localities.

**Areas of production**
Collected from wild and is being cultivated at wet marshy localities throughout India.
Plant products

*Crude:* The dried herb as such or in powder form is sold in the market.

*Semi-processed:* The dried herb is powdered and sold as such by some pharmaceutical firms manufacturing Ayurvedic OTC formulations. It is also used for the preparation of 'Brahmi Ghrita'.

*Processed:* Mentat (Mind care), Mentat syrup, Anxocare, Brahmi and many other formulations are available in Indian market.

The information on cultivation harvesting, pre and post harvest care, conservation and value addition is available with following research centers:

Central Institute of Medicinal and Aromatic Plants, Lucknow, Regional Research Laboratory, Jammu.

*Cultivation:* Regional Research Laboratory, Jammu has also developed a complete protocol for the micro propagation of *Bacopa monnieri*.

*Cultivars (including improved varieties):* Registration of three cultivars

1. **PRAGYASHAKTI:** This is selection from Orissa. The crop can be grown as perennial with at least two harvest per year. The yield of dry herb is 65 quintal/ha from which 118 kg/ha Bacoside A (1.8%) can be obtained in single harvest.

**COMPARATIVE PHYTOCHEMICAL ANALYSIS OF BACOPA MONNIERI L. IN VIVO AND VITRO CONDITIONS**
2. **SUBODHAK:** This is another selection from wild collections. The crop can be grown as perennial with at least two harvests per year. The yield of dry herb is 47 quintal/ha from which 77/kg ha Bacoside A (1.6%) can be obtained in single harvest.

3. **CIM-JAGRITI:** A variety recently developed has the potential of producing average 85 kg/ha of bacoside. A from an average dry herb yield of 40 quintal/ha.

4. **RRL, Jammu** has also developed and standardized a selection of a better cultivar type of this crop. The same is likely to be released very soon and the planting material of the same can be supplied under the consultancy package to the prospective entrepreneurs. Depending on the stage of harvest and the season, it contains 1.8 – 2.2% Bacoside A.

**Cultivation:** It can be easily grown in damp areas, and can be propagated by seed as well as vegetatively using runners. Rainy season is an appropriate time for planting of this crop. For getting optimum yields, 100 kgN/ha is applied whereas, 60 kg/ha of each of P2O5 and K2O are added to the field at the time of planting. A light irrigation is needed after the planting. After harvesting the crop is shade dried for marketing.

Central Institute of Medicinal and Aromatic Plants, Lucknow has developed agrotechnology for cultivation of *Bacopa monnieri* in India.

**Collection:** The whole herb is generally collected after the rainy season in the month of September from the wild localities of its natural distribution near the water falls or marshy places. However, when under cultivation, it is harvested in October – November split dozes.
Conservation: Bacopa monnieri is one of the plants among 32 medicinal plants identified for cultivation, conservation and development by the National Medicinal Plants Board.

A Bangalore based Foundation for the Revitalization of Local Health Traditions (FRLHT) is also working on the conservation of various useful medicinal plants including B. monnieri by growing them in home gardens.

Phyto-Pharmaceuticals: Bacoside A is available as per demand for Regional Research Laboratory, Jammu. In addition standardized extract of B. monnieri with 20% Bacosides A and B is also sold by some of the herbal drug dealers.

A major problem in the process of producing bacosides is the difficulty of obtaining the final product in the form of stable dry free flowing powder as the active constituents (bacosides) are highly unstable and hygroscopic. Patented process developed by Central Institute of Medicinal and Aromatic Plants, Lucknow is able to produce extract of B. monnieri as a highly stable, dry, free flowing powder (Kahol et al., 2005).

Herbal drugs: A standardized herbal preparation from B. monnieri for the improvement of memory is being marketed under the brand name 'Promind' by M/s Lumen Marketing Company, Chennai. This technology has been developed by Central Drug Research Institute, Lucknow. Some other products in market include Mentat (MindCare), Mentat syrup, Anxocare, and Brahmi.
SCIENTIFIC INFORMATION

The entire plant constitutes the well-known drug Brahmi which is extensively used to improve the intellect and as memory enhancer. The juice of the leaves is given to children for relief in bronchitis and diarrhoea. The paste of the leaves is used as a remedy for rheumatism. The leaves and tender stalks are reported to be eaten in the West Bengal. Its juice along with ginger juice, sugar and bark extract of *Moringa oleifera* is given to children in stomach disorders.

ETHNO-BOTANICAL INFORMATION

The drug is used for enhancing power of speech, arresting process of aging and overcome conditions of stress. It is employed in the preparation of Brahmi grita prescribed in cases of epilepsy and hysteria in Bengal. Small quantities of brahmi juice taken internally bring peace to the mind and also help in nourishing and strengthening of brain. Also in the case of insanity, epilepsy and biliousness its ghrita or medicated ghee is given with pushkaramul (*Sauseria lappa* root) and honey. Leaves of Brahmi fried in ghee are eaten to cure hoarseness of the voice.

PHARMACOLOGICAL STUDIES

Reports show that this drug (standardized plant extract) is an anti-anxiety agent having adaptogenic effect. It exhibits barbiturate hypnosis potentiation effect in albino rats. The saponin, hersaponin, is reported to possess cardiotonic, sedative and spasmodic properties. It produced a mild inhibitory effect on the respiration of rat brain tissue which was partially reduced by LSD – 25 and potentiated by 5-HT. an alcoholic
extract of the plant, in a dose of 50 mg/kg, produced a tranquilizing effect on albino rats and dogs but the action was weaker than that produced by chlorpromazine. An ethanolic extract (50%) of the plant exhibits anti-cancer activity against Walker carcinosarcoma 256 in rats. Administration of aqueous suspension of an alcoholic extract (40 mg/kg, p.o) for three or more days is reported to improve the performance of rats in various learning situations.

IMPROVEMENT

The authentication of the traditional claims of brahmi as nerve tonic for improvement of memory was done by investigating the effect of an alcoholic extract of this plant on acquisition, consolidation and retention of three newly acquired behavioral responses in albina rats viz... a foot shock motivated brightness discrimination response, active conditioned avoidance response and Sidman continuous avoidance response. The facilitatory effect of the brahmi extract (40 mg/kg, p.o X 3d) was manifest in all the three learning responses as it augmented both the cognitive function and mental retention capacity. The chemical constituent responsible for the facilitatory effect of brahmi on learning schedules was identified as a mixture of two saponins designated as bacosides A and B.

EFFECTS

The current interest in the anxiolytic properties of standardized Brahmi extract (25.5% bacosides) assumes greater relevance in view of the fact that Bacopa monniera promotes cognition unlike the amnesic action of benzodiazepine anxiolytics. The effects of B. monniera extract at levels of 5, 10 and 20 mg/kg administered orally to rats were compared to those
elicited by lorazepam (0.5 mg/kg administered intraperitoneally). The higher doses of this extract produced significantly greater anxiolytic effects compared to lorazepam.

PROTECTANT

The protective effect of B. monniera on morphine induced liver antioxidant levels has been studied in rats. Oral administration of alcohol extracts of B. monniera induced a significant hepatoprotective effect. A significant increase of lipid peroxidation and a significant decrease in liver antioxidant enzyme levels is also observed. It is now well known that *Bacopa monniera* alcohol extract exerts a hepatoprotective effect against morphine induced liver toxicity.

CHEMICAL CONSTITUENTS

![Chemical structures of Bacopside A and Bacopside A1](image)

**MAJOR CHEMICAL CONSTITUENTS OF BACOPA MONNIERI**
The herb contains the alkaloids brahmine, herpestatine, \((C_{34}H_{46}N_{206}, \text{m.p. 116-170}^\circ C)\), and a mixture of three bases. The herb also contains saponins, monnierin \((C_{51}H_{82}O_{213}, \text{m.p. 630}^\circ C)\); hersaponin \([\text{m.p. 232 – 340}^\circ C \text{ (decomp).}]\), bacoside A \([C_{41}H_{68}O_{13}, \text{m.p. 2500}^\circ C \text{ (decomp.)}]\) and bacoside B \([C_{41}H_{68}O_{13}, \text{m.p. 2030}^\circ C]\). Monnierin, on hydrolysis, gave glucose, arabinose and aglycone \((C_{30}H_{48}O_{4}, \text{m.p. 235 – 370}^\circ C)\) whereas, bacosides A and B gave glucose, arabinose and bacogenines A, A2, A3 and A4; bacogenines A1 and A2 are epimers, and A4 is an ebolin lactone. Smith – de Mayo degradation of bacoside A gave jujubogenin and pseudojujubogenin. Bacosides A and B possess haemolytic activity.

Other constituents present in plant are D – mannitol, betulic acid, b-stigma sterol and its esters, heptacosine, octacosane nonacosane, triacontane, hentriacontane, dotricontane, nicotine, 3 – formyl – 4 hydroxy – 2H – pyran \((C_{6}H_{5}O_{3})\), luteolin and its 7-glucoside. The presence of a – alanine, aspartic acid, glutamic acid and serine is also reported. Isolation of apigenin – 7 – glucuronide and luteolin – 7 – glucuronide from leaves; a new minor saponin – bacoside A1 – isolated and characterized as 3-o-a-L-arabinofuranosyl (1-3)-a – L – arabinosyl – jujubogenin; isolation of another saponin – bacoside A3 – and its structure elucidate as 3-o-b-D-glucosyl (1-3) – [o-(a – L – arabinofuranosyl (1-2) – 0 –b – D glucosyl]jujubogenin; revision of structure of cis – isomer of beeline lactone, obtained during acid hydrolysis as another artifact of jujubogenin.

Analysis of the leaves and stalks gave: moisture, 88.4; protein, 2.1: fat, 0.6; carbohydrates, 5.9; crude fiber, 1.05; and ash, 1.9 g/100 g. calcium, 202.0; phosphorus, 16.0; iron, 7.8; ascorbic acid, 63.0; nicotinic acid 0.3 mg/100g; and energy, 38 cal/100g. The leaves contain a sterol \(C_{26}H_{46}O.H_{2}O, \text{m.p 76}^\circ C)\).
CHEMICAL MARKERS

The drug is characteristically designated on the basis of its total bacosides content which are tetra cyclic triterpenoid saponins Bacoside A and B.

QUALITY CONTROL

Dried, whole herb or herb without roots or only leaves and tender stem portions are available as crude drug. The dried crude drug is yellowish in colour with majority of leaves detached.

SAFETY DATA

Brahmine an alkaloid present in Brahmi, is highly toxic; when administered at a dose of 0.5 mg/kg body wt of cat as it produces a fall in the blood pressure.

Brahmi possess no known side effects or toxicity at normal doses. In experimental studies, the saponin – rich highly potent extract of Brahmi did not show any endocrine, metabolic, gastrointestinal, anabolic or behavioural side effect.

CLINICAL TRIALS

Clinical Studies in school children for over three year have not shown any adverse side effect. In healthy human volunteers multiple doses of bacosides (the active ingredient in Brahmi) have been well tolerated and are devoid of any untoward reaction or side effects.
Bacosides were also found to be safe in regulatory pharmacological and toxicological studies and were well tolerated by normal healthy male human volunteers in single dose (20 – 300 mg) and multiple doses (100 and 200 mg) administered for 4 weeks in double blind placebo controlled and non-crossover regulatory Phase – I clinical trial.

**DOSAGE**

Infusion: 8 – 16 ml per Powdered drug: 5-10 g per day to repeat it.

**TAXONOMY**

**Kingdom:** Plantae  
**Division:** Magnoliophyta  
**Class:** Magnoliopsida  
**Order:** Lamiales  
**Family:** Scrophulariaceae  
**Genus:** Bacopa  
**Species:** *B. monnieri*  
**Vernacular name:** Brahmi, jalneem  
**English name:** Bacopa  
**Binomial name:** *Bacopa monnieri* (L) Wettst.

**Sanskrit:** Brahmi, Nira brahmi; Hindi: Brahmi; English: Brahmi-sak; Bengali: Jalanimba; Kannada: Nirubrahmi; Malyalam, Marathi and Tamil: Neer brahmi; Telugu: Sambrani chettu; Marathi: Jalmaveri

A Glabrous, somewhat, succulent, creeping small herb, rooting at the nodes with numerous prostrate branches, each 10-30 cm long flowers purple green.
**Leaves:** Oblong to spathulate Sessile Decussate 1-25*0.3-0.8 Fleshy Entire Punctuate Obtuse.

**Flowers:** Auxiliary Solitary Pendundes 1-1.5 cm long Often much longer and deflexed in fruiting stage Bracteoles 5 mm long, Linear, obtuse, Purple blue color.

**Fruit:** A capsule 5 mm long Ovoid Glabrous

**Seed:** Pale Minute Oblong Striate

**HABITAT AND BOTANICAL DESCRIPTION**

*Bacopa monnieri* has originated in India. A genus of spreading herbs, commonly growing in damp and marshy places throughout India, ascending up to an altitude of 1,320 m, a small creeping, glabrous, succulent, herb rooting at nodes. Stem soft obtuse – angular, branches ascending, leaves are sessile, opposite decussate, succulent, obovate or ob lanceolate in shape, short petiolate, 0.6 – 2.5 cm in size, flowers solitary axillary, blue or white in color with purple veins, campanulate, pentamerious, capsules ovoid (Mathur and Kumar, 1998). Flowers and fruits appear in summer. Whole plant forms the medicinally useful part.

**PROPAGATION AND AGRONOMY**

*Bacopa monnieri* spreads by producing new plants on above ground runners. The new plants can be separated from the parent plant once they have taken root. The natural regeneration of this herb is hampered by
depth of seedlings at 2-leaved stage and specific habitat (marshy areas) requirements. *Bacopa* seems to be poor competitor and so it can colonize open spaces only (Tiwari et al., 2000). A field trial involving five Indian accessions of *Bacopa monnieri* was conducted during 1997 to 1998, at Lucknow, Uttar Pradesh, India, to standardize the cultivation procedure for the domestication of this medicinal herb. The accessions monitored for growth and bacoside – A yields over 18 months, could be maintained as perennials, but growth properties were sensitive to the growing season. Loss of shoot biomass occurred in winter (December – February) and the growth rate was higher in the monsoon season (July – September) than in summer (March – June). Bacoside – A content of herb was high from September through March and in June. Suitable harvest times for high yields of bacoside – A were June and September through November. An accession from Guwahati in Assam state of India yielded more bacoside – A than all other accessions (Mathur et al., 2002).

**CHEMISTRY**

Plant contains two saponins, bacoside A and B. in addition to the bacosides, *Bacopa* contains a wide variety of medically active substances, including stigmasterol, sapogenins, and flavonoids. Other compounds include triterpenoid saponins. *Bacopa* also contains D – mannitol, betulic acid, beta – sitosterol, octacosane, nicotine, and amino acids such as alpha – alanine, aspartic acid, glutamic acid, and serine. Alkaloids such as Brahmins, Herpestine and a mixture of three alkaloids were reported from the leaves of this plant.

The carbohydrate mostly of bacoside A was shown to be arabinosyl glucose with the arabinose unit as the terminal sugar. Bacoside B was
found to be dextorotatory where as bacoside A was laevo rotatory. The haemolytic action of bacoside B is twice that of bacoside A (Report on Herbal industry, pp: 37-41). This is because of the differences in the configuration of the carbohydrate parts. Bacosome A yields bacogenins A1, A2, A3 and A4 upon hydrolysis (Chatterji et al, 1965). The other chemical constituents of the plant includes bacoside A1, hersaponin, betulinic acid, stigmasterol, b-sitosterol and stigmastenol (Chatterji et al, 1963; Jain and Kulshreshtha, 1993).

Chemical constituents including known chemo-types. The herb contains the alkaloids brahmine, herpestatine, \((C_{34}H_{46}N_{2}O_{6}, \text{ m p 116 – 170C})\), and a mixture of three bases. The herb also contains saponins, monnierin \((C_{51}H_{82}O_{21-3}H_{2}O, \text{ m p 630 C})\); hersaponin \([\text{ m p 232 – 340C (Decomp)}]\), bacoside – A \([C_{41}H_{69}O_{13}4H_{2}O, \text{ m p 2500 C (decomp.)} and bacoside – B; [C_{41}H_{68}O_{13}5H_{2}O, \text{ m p 2030 C. monnierin, on hydrolysis, gave glucose, arabinose and aglycone (C}_{30}H_{48}O_{4}, \text{ m p 235 – 370C) whereas, bacosides A and B gave glucose, arabinose and bacogenines A, A2, A3 and A4; bacogenines A1 and A2 are epimers, and A4 is an ebelin lactone. Smith – de Mayo degradation of bacoside A gave jujubogenin and pseudojujubogenin. Bacosides A and B possess haemolytic activity.

Other constituents present in plant are D – mannitol, betulic acid, B-sitosterol. Stigmasterol and its esters, heptacosine, octacosane nonacosane, triacontane, hentriacontane, dotriacontane, nicotine, 3 – formyl -4hydroxy-2H-pyran \((C_6H_6O_3)\), luteolin and its 7-glucoside. The presence of a – alanine, aspartic acid, glutamic acid and serine is also reported.
Isolation of apigenin-7-glucuronide and luteolin-7-glucuronide from leaves; a new minor saponin-bacoside A1- isolated and characterized as 3-o-a-L-arabinofuranosyl (1-3)-a-L-arabinosyl-jujubogenin; isolation of another saponin – bacoside A3- and its structure elucidated as 3-0-b- D – glucosyl (1-3)-[o-(a-L arabinouranosyl (1-2) – 0-b-D- glucosyl-jujubogenin; revision of structure of cis – isomer of ebeline lactone, obtained during acid hydrolysis as another artifact of jujubogenin.

Analysis of the leaves and stalks gave: moisture, 88.4; protein, 2.1: fat, 0.6; carbohydrates, 5.9; crude fiber, 1.05; and ash, 1.9 g/ 100g. calcium, 202.0 ; phosphorus, 16.0; iron, 7.8; ascorbic acid, 63.0; nicotinic acid 0.3 mg/100 g; and energy, 38 cal/100g. The leaves contain a sterol C_2H_46O.H_2O, m p 76 0C).

HISTORY

Brahmi is a well known drug in the Ayurvedic medical tradition in India, and is used in many Ayurvedic herbal preparations. It has been traditionally used to treat asthma, hoarseness, insanity, epilepsy, and as a nerve tonic, cardiotonic, and diuretic. It was prominently mentioned in Indian texts as early as the 6th century A.D.

In the folklore of Indian medicine, certain herbs have been used traditionally as brain or nerve tonics. One of the most popular of these used in neurotonics is Bacopa monnieri, a small, common, amphibious plant growing in marshy areas throughout the Indian subcontinent. Bacopa is also called Brahmi, name derived from Brahma, the creator God of the Hindu pantheon of deities. It is legendary for its diversity of usage. In the
Ayurvedic Materia Medica, *Bacopa* has been recognized for its brain enhancement characteristics.

It is said that the use of *Bacopa* for memory enhancement goes back 3000 years or more in India, when it was cited for its medicinal properties, especially the memory enhancing capacity, in the Vedic texts *Athar – Ved samhita* (3:1) of 800 B.C and in Ayurveda. Back before written language, ideas and cultural values were transmitted by epic hymns or poems that were committed to memory and transmitted orally from one generation of Brahmins (the highest class of priests) to the next. *Bacopa* is reputed to have played a role in increasing the ability to memorize the great epic poems, possibly helping new generations to learn from the past and not make the same mistakes – a value spoken of by philosopher George Santayana then he wrote, “Those who cannot remember the past are condemned.

**LIST OF CHEMICALS**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Part</th>
<th>Lo ppm</th>
<th>Hi ppm</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-FORMYL-4-HYDROXY-2H-PYRAN</td>
<td>Plant</td>
<td></td>
<td></td>
<td>WO2</td>
</tr>
<tr>
<td>ALPHA-ALANINE</td>
<td>Plant</td>
<td></td>
<td></td>
<td>WO2</td>
</tr>
<tr>
<td>ARABINOSE</td>
<td>Plant</td>
<td></td>
<td></td>
<td>WO2</td>
</tr>
<tr>
<td>ASCORBIC - ACID</td>
<td>Shoot</td>
<td>630</td>
<td></td>
<td>WO2</td>
</tr>
<tr>
<td>ASH</td>
<td>Shoot</td>
<td>19000</td>
<td></td>
<td>WO2</td>
</tr>
<tr>
<td>ASPARTIC-ACID</td>
<td>Plant</td>
<td></td>
<td></td>
<td>WO2</td>
</tr>
<tr>
<td>BACOGENIN-A1</td>
<td>Plant</td>
<td></td>
<td></td>
<td>WO2</td>
</tr>
<tr>
<td><strong>Compound</strong></td>
<td><strong>Source</strong></td>
<td><strong>Value</strong></td>
<td><strong>Unit</strong></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------</td>
<td>-----------</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>BACOGENIN-A2</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>BACOGENIN - A3</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>BACOGENIN - A4</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>BACOSIDE-A</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>BACOSIDE-B</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>BETA-SITOSTEROL</td>
<td>Plant</td>
<td>100</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>BETULIC - ACID</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>BRAHMINER</td>
<td>Plant</td>
<td>2020</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAROHYDRATES</td>
<td>Shoot</td>
<td>59000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-MANNITOL</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>DOTRIACONTANE</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>FAT</td>
<td>Shoot</td>
<td>6000</td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>FIBER</td>
<td>Shoot</td>
<td>10500</td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>GLUCOSE</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>GLUTAMIC-ACID</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>HENTRIACONTANE</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>HEPTACOSANE</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>HERSAPONIN</td>
<td>Plant</td>
<td>FT63(5):</td>
<td>399</td>
<td></td>
</tr>
<tr>
<td>IIRON</td>
<td>Shoot</td>
<td>78</td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>JUJUBOGENIN</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>KILOCALORIES</td>
<td>Shoot</td>
<td>380</td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>LUTEOLIN-7-GLUCOSIDE</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>MONNIERIN</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>NICOTINE</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>NICOTINIC-ACID</td>
<td>Shoot</td>
<td>3</td>
<td>WO2</td>
<td></td>
</tr>
<tr>
<td>NONACOSANE</td>
<td>Plant</td>
<td></td>
<td>WO2</td>
<td></td>
</tr>
</tbody>
</table>
MEDICINAL USES

In India the plant is used for all sorts of skin problems – eczema, psoriasis, abscess, ulcerations – it is said to stimulate the growth of skin, hair and nails. Indian Pennywort is also used for chronic rheumatism often as an ointment. In Pakistan, the herbal drug, Brahmi-buti, is used to treat skin diseases, leprosy, epilepsy, eczema, asthma, hoarseness of the voice, and diseases of the nervous system (Shakoor et al, 1994). According to scientists at the Central Drug Research Institute in Lucknow, India, certain "memory chemicals" in Bacopa, called bacosides A and B, help repair damaged neurons by enhancing proteins involved in the regeneration of neural – cell synapses (Rastogi et al, 1994).

These are the relay stations of the brain that facilitate the transmission of neural impulses. Thus Bacopa can be viewed as a neural nourisher, restoring depleted synaptic activity and leading to enhanced memory function. In scientific studies, it has been shown to exert a remarkable and
unique effect on neurotransmitters. *Bacopa* may even be able to revitalize intelligence.

Among its many other applications, *Bacopa* has reportedly been effective in reducing anxiety levels, thereby allowing for further improvement of brain functioning and elevated mental performance. It is also believed to help stabilize the brain waves of epileptics. *Bacopa* is recognized as a treatment for asthma, bronchitis, and hoarseness. In other parts of the body, it has been used successfully as a remedy for rheumatism, for diarrhoea, and a diuretic (increasing urinary flow).

**EFFECT AS A MEMORY ENHANCER**

Recent research has confirmed what practitioners of Ayurveda have known for over a thousand years – that *Bacopa monniera* significantly enhances memory. This is especially true in children.

- **Effect on Central Nervous System:** Researchers believe that *bacopa* has the ability to stimulate gamma – aminobutyric acid (GABA), an amino acid that occurs in the central nervous system and that is associated with transmission of inhibitory nerve impulses. This enhanced ability to synthesize GABA leads to improved acquisition, memory and adaptation to new conditions.

- **Effect on Epilepsy and Anxiety:** *Bacopa* has been used for centuries in Ayurvedic medicine as a remedy for epilepsy. Western studies have shown that it does, indeed, have an anticonvulsant effect when administered at high doses. The supplementation with *bacopa* extract has also led to significant decreases in anxiety symptoms, levels of anxiety, levels of disability and mental fatigue.
Significantly, these benefits occurred in the absence of the amnesiac side effects associated with many popular anxiety related drugs (i.e. Lorazepam). On the contrary, memory enhancement was achieved.

- **Effect on Alzheimer’s:-** By inhibiting the breakdown of the enzyme cholinesterase, a key neurotransmitter which fails in cases of Alzheimer’s and dementia, *Bacopa* has the potential to positively affect sufferers of these conditions.

- **Effects on Bronchitis and Asthma:-** *Bacopa* has been shown to have relaxant effect on chemically induced bronchoconstriction. Animal studies have also demonstrated that *Bacopa* has potent mast cell stabilizing ability with a resultant potential to control asthma and allergies. Human trials are needed to confirm these potential benefits.

- **Effect on Cancer:-** In vitro research points to some exciting benefits for cancer patients. It has been demonstrated that *Bacopa* saponin fractions have cytotoxic activity for sarcoma 180 cells. Researchers believe this is due to bacopa’s ability to inhibit DNA replication in the cancerous cell line.

- **Other Benefits:-** Bacopa extracts have shown potential to inhibit calcium flux across cell membrane channels. This suggests that Bacopa can provide relief for those who suffer from conditions resulting from intestinal spasm, such as irritable bowel syndrome. Bacopa may have a curative effect upon gastric ulcers. *Bacopa* has a stimulatory effect upon thyroid function, thus benefiting sufferers of hypothyroidism. Bacopa extracts also have potential to diminish the side effects of certain drugs, including morphine and phenytoin.
Historically in India the leaves of the *Bacopa monniera* plant were used to treat skin conditions, anaemia, sprains, fractures, diabetes, hemorrhoids, and asthma as well as cough and rheumatism. The plant is also used to increase fertility and prevent miscarriage (No author listed). The Wealth of India: Raw Materials. II-B. New Delhi: Publications and Information Directorate, CSIR, 1950: 2-3).

**MEDICINAL PROPERTIES**

**How Bacopa Monniera Works**

*Bacopa's* ability to positively impact upon cognitive ability appears to be due to the enhancement of nerve impulse transmission as a result of the actions of triterpinoid saponins and their bacosides, specifically bacosides A and B. Damaged neurons are repaired by these bacosides due to their ability to enhance kinase activity, neuronal synthesis and restore synaptic activity.

*Bacopa* extracts have been shown to modulate the expression of certain enzymes involved in generation and reactive oxygen species in the brain.

Bacopa has a relaxant effect upon pulmonary arteries, the aorta, trachea and ileal and bronchial tissue as a result of inhibition of calcium – ion flux into cell membranes. Its ability to inhibit prostaglandin synthesis and to stabilize lysosomal membrane give it an anti-inflammatory ability. Bacopa also increases serotonin levels. Serotonin is a neurotransmitter that promotes relaxation.
Bacopa’s antioxidants also appear to have a protective effect upon human DNA connective tissue cells (fibroblasts), suggesting that it may have benefits in treating diseases where free radicals are an issue.

Bacopa inhibits the enzyme cholinesterase. Cholinesterase breaks down acetylcholine, which is neurotransmitter which fails in Alzheimer’s patients.

**Research Based Actions of Bacopa Monniera**

*Bacopa* is famous for enhancing memory, improving learning skills, for anxiety, stress and depression. Modern studies find it useful in several other ways.

This ayurvedic herb is found useful as anti-oxidant capable of free radical scavenging, preventive for ulcer in stomach and duodenum, as anti – Helicobacter pylori, adaptogen, anti-fungal, for IBS, as Broncho-vasodilator. It can be beneficial in drug toxicities as well.

**Bacopa As An Anti-Oxidant**

This medicinal herb is found to extend antioxidant protection for brain centers from stress. Bacosides are supposed to protect the synaptic functions in the hippocampus of brain which is the seat of memory.

*B. monnieri* inhibit experimentally induced lipid peroxidation. This oxidation of lipids by free radicals is damaging as it leads to
formation of arteriosclerotic plaques in blood vessels. B.monnieri also acts as metal chelator i.e. it removes the excess of harmful metals from blood and thereby limit the propagation of free radicals.

**Bacopa & Free Radical Scavenging And Preventing DNA Damage**

In this study B.monniera showed dose dependent free radical scavenging activity and a protective effect on DNA cleavage. This antioxidant activity might reveal partly its anti-stress, immunomodulatory, cognition enhancing, anti-inflammatory and rejuvenative effects.

In another study at University of Catania, Italy, researchers found that at least due to its antioxidant properties it would be useful in treatment of pathologies where free radicals play an important role.

In vitro studies found cytotoxic activity for Sarcoma – 180 cells in Saponin fraction of B.monnieri. It might be due to inhibition of DNA replication in cancer cells. Further studies in men are needed to explore this effect.

**Preventing Ulceration In Stomach & Duodenum**

In one study on rodents, it was found to be effective to protect the stomach for ulcer formation.
In another study, the administration of B.monnieri was found to prevent ulceration by various offensive and defensive mechanisms by both normal and NIDDM rats. However the effect of B.monnieri was more prominent in normal rats and that of Azadirachta was prominent on NIDDM rats.

In this study B.monnieri was found to augment defensive mucosal factors like increased mucus secretion, prolonged life span of mucus membrane cells and gastric antioxidant effects. It also showed in vitro anti-Helicobacter pylori activity, and increased in vitro Prostanoids (PGE2, PG12) that are responsible for its anti-ulcerogenic effect.

Studies on animals and men confirmed its prophylactic and curative role for gastric ulcers. A 20 mg/kg dose for 10 days healed penetrating ulcers, strengthened mucosal barrier and minimized exfoliation of mucus membrane. It was found to be effective in stress ulcers as well.

**Bacopa As Anti-Helicobacter Pylori**

Another in vitro study demonstrated its effect as specific antimicrobial activity against Helicobacter pylori. H. pylori is associated with chronic gastric ulcer. With administration of B. monnieri, PGE and Prostacyclin were also found to accumulate and these are known to be protective for gastric mucosa.
**Bacopa As An Adaptogen**

Investigators found in *B. monnieri* potent adaptogenic property for both acute and chronic stress in rats. Pretreatment with it reduced the acute state induced stress and significantly reduce the chronic stress induced increase in ulcer index and adrenal gland weight like indicators.

In another study at Central Drug Research Institute, Lucknow, India, the researchers found *B. monnieri* to be effective in acute and chronic stress.

**Bacopa As Anti-Fungal Agent**

The phytochemicals betulinic acid, wogonin and oroxindin from aerial part of *B. monnieri* were found to have anti-fungal activity against *Alternaria alternate* and *Fusarium fusiformis*. This study was conducted at CDRI, Lucknow, India.

**Bacopa For IBS Or Irritable Bowel Syndrome**

In vitro studies in both animals and man demonstrated direct anti-spasmodic activity on smooth muscles of intestine. This effect was mediated by inhibition of calcium ions influx in cell membranes.

However in another double blind placebo controlled trial on 169 patients with IBS, the effect of *B. monnieri* and *Aegle marmelos* was compared to *Clinidium bromide*, *Chlordiazepoxide* and *Psyllium*. The herbal combination was found to be superior in IBS with diarrhoea.
The benefit was probably more due to A.marmelos. yet the combined botanicals were far effective than placebo.

**Bacopa As Broncho-Vasodialator**

This study concluded that various constituents of *B.monniera* produced **significant broncho-dilatation in anesthetized rats**. There was relaxant effect on pulmonary arteries, trachea, aorta and bronchial tissues that was possibly mediated by inhibiting of Calcium ion entry into cell membrane.

Another in vitro study demonstrated *B. monnieri* to possess potent mast cell stabilizing activity comparable to disodium chromoglycate. These studies strengthened its claim to be effective in Bronchial Asthma and allergic rhinitis.

**Bacopa Effects on Cardiovascular System**

There had been no studies in this regard. In vitro studies in rabbits showed vasodilatation effect in pulmonary artery and aorta. In another study there was mild decrease of Systolic blood pressure from an average of 118 mm of Hg to 112 mm of Hg.

**Bacopa & Thyroid**

The study on mice demonstrated *B.monnieri* to be effective in directly **stimulating synthesis or release of T4 at the glandular level**. There was no effect on T3. However the dosage was 200 mg/kg/daily and this is far greater than the dose given to man (200 to 500 mg daily). It could not be used in human for increasing the T4 thyroid hormone due to excessive dose requirement.
**Bacopa protection from Drug Toxicity**

*B. monnieri* can be effective to counteract the side effects of some drugs. In vitro study on guinea pig ileum found it to be effective in drug induced morphine withdrawal. One mg per ml extract was found to reduce the naloxone induced side effects. Other studies suggested this effect to be due to anticholinergic and calcium antagonistic activity.

Another study on rats found it to be effective in morphine induced hepatotoxicity as that was measured by lipid peroxide accumulation and antioxidant enzyme levels. The results of this experimentation supported its protective effect on morphine induced toxicity.

Other researchers found similar effects on brain mitochondrial activity of morephine treated rats.

**Bacopa Reducing Nociceptive Response**

Nociceptive receptors are the nerve ending that receive and transmit painful stimuli. *B. monnieri* is found to reduce nociceptive response. This hypersensitivity to pain is found in many somatic and visceral nerves as in Cancer. With other beneficial effects as adaptogen, anti-DNA replication, antioxidant, this herb can be used as adjuvant in treatment of Cancer.

This effect can be useful in headaches that are associated with worry and tension.
ANTIDEPRESSANT ACTIVITY

The standardized extract was reported earlier to have significant anti-oxidant effect, anxiolytic activity and improve memory retention in Alzheimer’s disease. Presently, the standardized methanolic extract of Bacopa monniera (bacoside A) was investigated for potential antidepressant activity in rodent models of depression. The effect was compared with the standard antidepressant drug imipramine. The bacopa extract when given in the dose of 20 and 40 mg/kg, orally once daily for 5 days was found to have significant antidepressant activity in forced swim and learned helplessness models of depression and was comparable to that of imipramine.

ATTENTION – DEFICIT DISORDER

Another application comes from clinical reports of Bacopa’s use for attention – deficit hyperactivity disorder (ADHD) in children. In a study conducted at BRD Medical College at Gorakhpur, 36 children in the 8-10 years age group were selected for double blind, randomized trial (Mishra, 1980). While 19 were given 50 mg of Bacopa twice daily, 17 others received placebo. After 12 weeks of treatment, the children were subjected to a battery of specialized tests. The data revealed a significant improvement in the areas of sentence repetition, logical memory, and pairassociative learning (matching things that go together; e.g., “test” and “grade”) in all 19 ADHD children who took Bacopa.
ANXIETY AND BLOOD PRESSURE

Singh and Singh (1980) reported that for four weeks, 35 patients were treated for anxiety neurosis. After treatment, they were assessed for clinical anxiety levels, maladjustment level, mental fatigue rate, and immediate memory span. In those patients receiving Bacopa anxiety levels were lowered by about 20%. Maladjustment was significantly lower than its corresponding pretreatment value. Mental fatigue, as determined in total daily work output, was lower. Immediate memory-span scores were significantly increased.

ECONOMIC IMPORTANCE

- Environmental: ornamental
- Medicines: folklore
OBJECKTIVE OF THE STUDY

The main objective of present study is to find out effect of vitro conditions on biochemical constituent. Hence an immediate need for accessing the natural population leading to rapid multiplication on this important drug yielding plant has become imperative. The characteristics of rapid vegetative growth, available morphological variation and short sexual life cycle has led to the possibilities of using Bacopa monnieri in the developmental studies relating to bioprospection.

The present study has been initiated developing micropropagation after accessing the response of different explants (node apical meristem and leaf explants) and find out suitable media with and without supplementation of phytohormone in relation to chemical constituents. The technique would facilities rapid multiplication of this drug yielding plant, besides different biochemical parameters like estimation of chlorophyll, carbohydrate, total protein, lipid, phenol and ascorbic acid.
ENVIRONMENT OF DISTRICT GANGANAGAR

The district Sri Ganganagar having an area of 10,999 sq. Km is situated in the North of the Rajasthan State between 28°.49' – 30°.6' North latitude and 72°.36' – 74°.16' East longitude. This District constitutes a part of Great Indian Desert with District Bhawalnagar of West Pakistan in its North – West and districts of Ferozepur of Punjab and Hissar of Haryana on its North – East and Hanumangarh of Rajasthan on its East. To its South lies the desert district of Churu and Bikaner. The International boundary of Pakistan forms the North and Northwestern boundary. Prior to 1927-28, the District was an extreme desolate land, vast expanse of undulating sand dunes with extremely meagre rainfall, during some years even less than 10 cm. The District Sri Ganganagar includes the following tehsils:

1. Sri Ganganagar
2. Sri Karanpur
3. Sadulsahar
4. Padampur
5. Rai Singhnagar
6. Anupgarh
7. Vijaynagar
8. Suratgarh
9. Gharsana

The material was collected thrice in a year from the irrigated and non-irrigated areas from each site. The visit was particularly made during the rainy season.

Climate

The District Ganganagar has a desert type of climate with large variations of temperature, extreme dryness and scanty rainfall. It has both extremities of climate, as it is too hot during the summers and very cold and dry in
winters. The cold season from November to March is followed by summer from April to June. July to mid – September constitutes the southwest monsoon season. Mid – September is the transitional post monsoon period. The weather is mild and pleasant during September and October. Hot winds continue to blow in summer during day sweeping away the old, and creating new sand dunes. With the setting of the sun, the sand loses its temperature swiftly, and nights become cool and pleasant to bestow refreshing repose to the shattered nerves. The winters are equally severe and biting with the temperature sometimes touching the freezing point at night.

**Temperature**

There are two meteorological observatories in the district, one at Anupgarh and the other at Sri Ganganagar.

**Summer Season**

Temperatures rise rapidly after March. June is the hottest month with the mean daily maximum temperature recorded as 42.1°C. the scorching heat in the summer season with the frequent, dust laden winds in intense and the day temperatures sometimes go up to 50°C. Sri Ganganagar is one of the hottest parts in India in summer.

**Monsoon Season**

With the advance of southwest monsoon by the middle of July temperatures decrease a little. During July to September, the temperature is decreased due to monsoon rains but there is not much difference in
temperature of day and night. Usually by the first week of July the first
monsoon arrives and the average maximum temperature of this month
comes down to 38.8°C which further decreases to 37.7°C in August. With
the withdrawal of the monsoon by the latter half of September both day
and night temperatures being to decrease; the drop in the night
temperatures being more rapid. During October, the day temperature
remains high with a drop in the night temperature.

**Winter Season**

The diurnal range of temperature is very large, particularly in the winter
months and the drop in the temperature after nightfall is rather sudden.
January is the coldest months with the mean daily minimum temperature at
4.7°C and the mean daily maximum at 20.5°C Due to the western
disturbances moving across North India during the winter season, cold
waves affect the district and the minimum temperature sometimes drop to
2°C or 3°C below the freezing point of water and frosts occur. The average
minimum temperature for the year is recorded during the winter months.

As Ganganagar is a part of Great Indian Desert, therefore May and June
are the hottest months with temperature rising up to 47°C while December
and January are the coldest months with temperature falling up to 2°C. The
mean minimum temperature for the year is recorded during the winter
months.

For the last three years in the district the mean minimum and maximum
temperatures recorded have been 4.3°C (December, 2005) and 44.1°C
(May, 2006) respectively. The summer months have been terribly hot with
dust-laden winds. During July to September the temperature decreases
due to monsoon rains. Usually by the first week to July first monsoon arrives and the temperature comes down to 38°C which further decreases in August.

**Rare Phenomenon**

The highest temperature recorded so far is 50°C in Ganganagar on 1934 June 14 and the lowest minimum is – 2.8°C on 1950 February 11.

**Range of Temperature**

Monthly absolute range of temperature (difference between maximum and minimum temperatures) during the last five years (2000 – 2005), has been highest in the month of November which is 20.5°C. The average maximum reaches 29.4°C while the average minimum temperature remains at 9°C. Though, June is the hottest month, the range is only 14.1°C. with the arrival of monsoon, the maximum temperature drops down, but the minimum remains more or less steady which makes the range lowest in the month August, i.e. 10.8°C. This is due to fact that the maximum drop in temperature is due to cooling effect of rainfall but the minimum temperature is not allowed to fall by the green house effect of cloudiness. In the following month of December, the range remains slightly narrower because the average maximum temperature also falls with the diminishing minimum temperature. From February onward, the temperatures gradually rise.
Rainfall

Sri Ganganagar has a comparatively dry type of climate. Southwest monsoon clouds are the main source of rainfall in the Great Indian Desert. The average annual rainfall in the district is 252.2 mm. In general the rainfall increases from the northwest to southeast. The annual rainfall varies from 190.8 mm at Sri Karanpur near the northwestern border to 345.5 mm at Bhadra near the southeastern border. About 82% of the rainfall is received during the period June to September. July and August are the rainiest months with some showers during the month of September and June. The variation in the annual rainfall from year to year is very large. On an average there are 16 rainy days with rainfall of 2.4 mm or more in a year in the district.

Rare Phenomenon

The heaviest rainfall in 24 hours recorded at any station in the district was 251.7 mm at Ganganagar on 1928 August 31. The heaviest rainfall recorded in the last three years has been 123.1 mm (June, 2006) and the minimum has been 1.2 mm (September, 2004).

Relative Humidity

Data on relative humidity for the last five years reveal that the highest values are observed in the month of August. Even during the rainy period the air is drier in between the rains. After the rainy season, the value of relative humidity decreases in September and October and then increase in November and December. The relative humidity starts decreasing abruptly from January and reaches its minimum in the month of April and
May when the relative humidities are of the orders 20% and 50% and then increases gradually from June to September. The average monthly pan evaporation fluctuates from 49.4 mm in Dec. to 337.6 mm in May.

The relative humidity has been as high as 96% (January, 2004) and as low as 20% (April, 2006) as recorded for the last three years.

**Atmospheric Sea Level Pressure and Winds**

The seasonal variation of atmospheric pressure over the state takes place in a systematic manner with a maximum in the winter (January) and a minimum in the monsoon season (July). The pressure gradient generally remains weak except during the late summer and monsoon season. Winds are generally light except for the period May to September when the pressure gradient rises from south to south west and the strength of winds also rises, and blow from directions between South and West. In July the pressure decreases from west/southwest to east/northeast over the state and correspondingly the winds become mainly from west to east. Winds are light during the period October to March with variable directions. October is the month of transition with weakest pressure gradient. In the afternoon winds strengthen slightly and blow mainly from directions between Northwest and Northeast. The average wind speed is 10Km/hr. Winds are strongest in the month of June and Weakest in November. In the arid tract they are sometimes violent with a maximum velocity of about 136 km per hour. In the month of July to September (Rainy Season) dust storms are followed by cold winds. During winter, cold winds blow from North to South, which has a killing effect on the aerial parts of the herbs. In April due to the rise in pressure from west to east the morning winds are variable in direction while in the afternoons they are mainly from direction...
between Southwest and North. Hailstorms are rare, may occur during April to June.

**Cloudiness**

The sky are moderately clouded on many days during the southwest monsoon season, overcast or heavily clouded sky prevailing only a few days. In the first of the year sky are lightly clouded or clear except during the winter months when, in association with the passing western disturbances, cloudy sky prevail for short spells of day or two. On an average the sunshine in summers is for 11-12 hrs and in winters is 5-6 hrs.

**Special Weather Phenomenon**

Some of the depressions which originate in the Bay of Bengal in the Southwest monsoon season and move in a westerly direction reach the district or its neighborhood during its last stages of activity and cause wide spread rain. An occasional post monsoon storm or depression may also affect the district. Frequent sand and dust storms and less frequently, thunderstorms occur in the hot season. Rain during the Southwest monsoon is also sometimes associated with thunder. During the cold season occasional fog occurs in the wake of western disturbances. During winter there are on the average ten frost days in a year.

**Geology**

The zone has geographical area of 20.6 hectares. There are no rocks or gravel soils in this district.
**Soil Types:** The major soil types are as follows

**Irrigated Alluvial Sierozem Soil**

These are deep to very deep soils and present in the canal command of the district. These soils have been derived from Alluvium of Shivaliks of Himalayan Sub Mountains mixed with Aeolian deposits of recent and sub-recent origin. The alluvium is of highly variable texture. These soils are yellowish brown to light grey, medium textured from sandy loam-to-loam and well drained. The upper soil may not be calcareous but the lower horizons are calcareous with accumulation of kankar nodules and lime. The soils are poor in organic matter and nitrogen status is very low. Such soil is found in the Gang Canal Command. The water table in the area is 10 m near canal and 20 m away from the canal. The ground water is generally saline.

**Ghaggar Flood Plain Soil**

These soils are confined to Ghaggar bed area of the zone. These soils are yellowish brown in color, loam to silty loam in texture with massive or blocky structure and are calcareous in nature. Stratification is common in these soils. Permeability and drainage condition of these soils range from moderate to poor. Salinity and alkalinity is widespread in patches. The seasonal river ‘Ghaggar’ passes the District through Suratgarh and Anoopgarh and leads to West Pakistan. This river contains water only in July and August and remains dry for the rest part of the year. During the rainy season, it floods large areas along its course and forms pools and puddles in which some aquatic vegetation comes up.
**Aeolian Sandy Soil**

These soils have originated by deposition of fine and loamy fine sand by winds. They are Calcareous deep, with sandy to loamy sand in texture and low in fertility. They are highly susceptible to wind erosion and have high rates of infiltration. These soils are scattered in Suratgarh, Anoopgarh and Sadulsahar tehsils.

**Tal Land**

These mostly occur in the inland basin and are mostly on gentle slopes. They are spread in small patches in Anupgarh and Suratgarh tehsils. These are medium to heavy textured soils and vary from good fertile land to salinity infested problematic soils. There are some saline areas near Jetsar and Anoopgarh, where a few halophytes occur.
Bacopa monnieri
Bacopa monneirii