Review

An overview of ethnopharmacological properties of *Boerhaavia diffusa*

Humayun Riaz¹*, Syed Atif Raza², Shahzad Hussain³, Sidra Mahmood⁴ and Farnaz Malik³

¹Department of Pharmacy, Sargodha University, Sargodha, Pakistan.
²School of Pharmacy, University of Punjab, Lahore, Pakistan.
³Drugs Control and Traditional Medicines Division, National Institute of Health, Islamabad, Pakistan.
⁴Department of Bioinformatics and Biotechnology, International Islamic University, Islamabad, Pakistan.

Accepted 5 December, 2013

Herbal medicines are used by traditional healers since hundreds of years, and medicinal plants are imperative reserve for traditional and herbal industry. This practice is in vogue since ancient times. Over 80,000 species of plants are used globally for their medicinal uses. *Boerhaavia diffusa* is one of the distinguished medicinal plants used to treat large number of human ailments. The plant in whole or its parts (aerial parts and roots) have abundant medicinal properties and are used by common and ethnic people for their common ailments. The investigated and reported pharmacological and therapeutic properties of *B. diffusa* include laxative and immunomodulatory activities, cancer chemopreventive efficacy, inhibition of tumorigenesis, antioxidant activity, hepatoprotective activity, hypoglycemic activity, anti-fungal, anti-proliferative, anti-estrogenic, analgesic, potent anti-fibrinolytic, antibacterial activity, anticonvulsant activity, diuretic, spasmylytic activity, anti-stress and dyspepsia. It has been studied with keen interest due to its promising medicinal values in phytochemical and pharmacological research field. The objective of this review on *B. diffusa* is to sum up plant morphology, chemical compositions, ethno-medicinal uses with a scope of development in future. The manifold benefits of *B. diffusa* has made it a true miracle of nature.

Key words: *Boerhaavia diffusa*, antioxidant, hepatoprotective, hypoglycemic, anti-fungal, anti-proliferative, anti-estrogenic, analgesic, antibacterial.

INTRODUCTION

*Boerhaavia* species has been studied extensively for its varied promising therapeutic effects due to its phytochemical and pharmacological investigational grounds. Hermann Boerhaave, a famous Dutch physician of the 18th century invented this plants (Chopra, 1969). *Boerhaavia diffusa* L. is a species of developing plant in the four o’clock family (Nyctaginaceae) which is generally recognized as tar vine. It is a persistent herbaceous plant growing in moist areas such as the India, South America and Antilles Africa (Correa, 1984). Individuals who are native to most of the Australian zone would use it like a net to capture small birds. Scientific names for *B. diffusa* are; *Boerhaavia repens* var. *diffusa*, Syn. *Boerhaavia repens* while family names are Horse Purslane, Hog weed. Various common Indian names used for *B. diffusa* are Mukaratee-Kirei (Tamil), Punernava (Telugu), Dholia-saturnoMoto-satoda (Gujarati), Snathikari (Hindi), Kommegida (Canarese), Tambadivasu (Marathi) and Varshabhu (Sanskrit) (Singh, 2007).

Genus *Boerhaavia*, comprising of 40 species is distributed in humid and subtropical regions and warm climate. It is found in Ceylon, America, Malay Peninsula, Australia, Sudan China, Africa and Islands of the Pacific. 6 of the 40 species of *Boerhaavia* are found in India,
namely *B. diffusa*, *Boerhaavia chinensis*, *Boerhaavia rubicunda*, *Boerhaavia hirsute*, *Boerhaavia erecta* and *Boerhaavia repanda*. Plant in India is found in hotter regions of the country and at the heights of 2,000 m in the Himalayan region. It is a persistent, dispersed hogweed, commonly occurring plentifully in waste places, waterways and dark places during rains (Najam et al., 2008).

**MORPHOLOGICAL PROFILE OF B. DIFFUSA**

It is a diffusely branched, young and straight herb. It shows a mode of vertical growth and covered axis which grows loose and the renewable shoots rise on the upper surface of it (Anonymous, 1999; Chaudhary, 2010).

**Roots**

Roots are firm, tuberous, plump, rod-shaped, thick, fusiform with woody stock and bearing rootlets. They are light yellow or brownish gray in color having unpleasant taste and contain 0.15% alkaloid named *B. diffusa* (Bhansali et al., 1978; Shrivastava and Padhya, 1995). 2 to 3 layers of parenchymatous cells are present in cortex, followed by 5 to 12 layers of thin-walled, oval to polygonal cells, numerous concentric bands of xylem tissue alternating with extensive region of parenchymatous tissue present below cortical regions, vessels generally found in groups of 2 to 8 in radial rows, having simple pits and reticulate thickening, tracheids, small, thick walled with simple depths, fibre prolonged, thick-walled, spindle shaped with pointed ends, phloem occurs as curved patches outside each group of xylem vessels and composed of sieve elements and parenchyma, wide zone of parenchymatous tissue in between two repeated rings of xylem elements composed of thin-walled more or less rectangular cells arranged in radial rows, central regions of root occupied by primary vascular bundles, several raphides of calcium oxalate, in single or in group present in cortical region and parenchymatous tissue in between xylem tissue, starch grains simple and compound having 2 to 4 components found in abundance in most of cells of cortex, xylem elements in parenchymatous tissue between xylem elements, simple starch grains mostly rounded in shape and measure 2.75 to 11 μ in diameter.

**Leaves and seeds**

The leaves are ovate-oblong, fleshy, or subcordate at the base and smooth above, having flat margins. The upper surface of the leaves is green, smooth and glabrous, though it is hairy white and pinkish below. Spongy parenchyma 2 to 4 layered with small air spaces, idioblasts comprising raphides, irregularly cluster crystal of calcium oxalate and orange-red resinous matter is present in mesophyll. Palisade ratio 3.5 to 6.5, stomatal index 11 to 16, and vein islet number 9 to 15. Cooked parts of plants are leaves, roots and seeds. They frequently can be ground into powder to complement with cereals when preparing bakery items (Anonymous, 1999). The seeds bud before the start of the rainy season.

**Stem**

Greenish purple, inflexible, trim, tube-shaped, swollen at nodes, young glabrous, often more than a meter long. Comprising of 9 to 12 stalked cells and an ellipsoidal head cortex which comprises 1 to 2 layers of parenchyma, pericycle 1 to 2 layered, thick-walled often comprising dispersed secluded fibers, stele containing countless small vascular bundles frequently linked together in a ring and several large vascular bundles spread in the ground tissue.

**Flowers and fruits**

Flowers are subcapitate, tiny, fascicled and pink. It is corymb, axillary and in terminal panicules, bracteoles, minor, acute, perianth tube limited above the ovary, inferior part greenish, ovoid, grooved, upper part pink, funnel-shaped, 3 mm long, tube 5 lobed, stamen 2 to 3. Fruit is glandular, narrowly oblong obovoid. Nut is one seeded, clavate is 6 mm in length, curved, broadly and bluntly 5 ribbed, viscidly glandular. These are sexless, pedicellate, pink or pinkish-red or white in color. In the place of a calyx and corolla; perianth is present, which is cylindrical in shape, the tube being short and narrow at the base and funnel-shaped at the top and surrounded above the ovary. The stigma is peltate. The achene fruit is removable, ovate, rectangular, young, five-ribbed and glandular, anthocarpous, and thick on the ribs (Thakur et al., 1989).

**PHYTOCHEMISTRY**

Flavonoids, alkaloids, steroids, triterpenoids, lipids, lignins, carbohydrates, proteins, and glycoproteins are present in this plant in large quantity. Punarnavine, boeravinone A-F, hypoxanthine 9-larabinofuranoside, punarnavoside, lirodendrin, ursolic acid and a glycol-protein having a molecular weight of 16 to 20 kDa have been isolated and studied in detail for their biological activity (Ahmad and Hossain, 1968; Lami et al., 1990; Mishra and Tiwari, 1971; Aftab et al., 1996). The herb and roots are rich in proteins and fats. Many retinoids have been isolated from the roots of the *B. diffusa* (Ahmed
et al., 1990; Lami et al., 1990; Lami et al., 1991; Kadota et al., 2012). *B. diffusa* also contains many boeravonones that is, boeravonone A, boeravonone B, boeravonone C, boeravonone D, boeravonone E and boeravonone F (Seth et al., 1986; Jain and Khanna, 1989). C-methyl flavone also has been isolated from *B. diffusa* roots (Guptha and Ahmed, 1984). Two known lignans including, liriodendrin and syringaresinol mono-D-glycoside, purine nucleoside hypoxanthine 9-Larabinose dihydrosofuroxanthe-borhavine; phytosterols about 0.04% of alkaloids known as punarnavine and punernavoside, about 6% of potassium nitrate, an oily substance and ursolic acid (Ojewole and Adesina, 1985; Lami et al., 1991; Ahmed and Yu, 1992). Phytochemical screening of the roots showed that the maximum alkaloidal contents (2%) gathered in the roots of 3-year old ripe plants. The herb comprises 15 amino acids, including 6 essential amino acids, while the root contains 14 amino acids.

**ETHNOMEDICINAL USES**

The Unani and Ayurvedic preparations made from *B. diffusa* are used for the management of several illnesses that is, anemia, stomachache, cough, cold, an expectorant and laxative. Roots are used as diuretic, laxative, expectorant and the leaves are used as an appetizer and alesthetic preparation. Seeds are used as energizer and for help in digestion (Aslam, 1996). It was included in list of TRAMIL, a research project on the medicinal plant resources of the Caribbean (Robineau and Soejarto, 1996), because of its use in Martinican as folk medicine agent for the treatment of pain in general and of sore throat in the form of juice of fresh leaves (Robineau, 1995). In Brazil, the plant was in use in the traditional medicine as diuretic (roots) and against snake venom (Lorenzi, 1994). The leaves of *B. diffusa* are used as a green vegetable in many parts of India. It cures ulcers of cornea, night blindness and helps to bring back virility in men (Gupta et al., 1962). People in tribal areas use it to accelerate childbirth (Shah et al., 1983). The plant is also consumed as vegetable as it is thought to be a rich resource of vitamins, minerals, protein and carbohydrate (Cho et al., 2004).

**PHARMACOLOGICAL AND BIOLOGICAL ACTIVITY**

The plant has gained lot of importance in the field of phytochemistry because of its various pharmacological and biological activities such as immunomodulatory effects, immunosuppressive, antimetastatic, antioxidant, antidiabetic, antiproliferative, antiestrogenic, analgesic, anti-inflammatory, antibacterial, antistress and adoptogenic activities. It is also reported to possess antilymphoproliferative, nitricoxidescavenging, hepatoprotective, anti-viral, bronchial asthma, anti fibrinolytic activities, chemopreventive action, genetic diversity analysis and anticonvulsant activity.

**Antidiabetic activity**

*B. diffusa* and ethanolic extracts exhibit significant antihyperglycemic activities in alloxan induced as well as streptazotocin induced hyperglycemic rats. They can also improve the condition of diabetes as indicated by parameters like body weight along with serum cholesterol and triglyceride levels. In the current studies, the damage of pancreas in streptazotocin treated diabetic control rats and regeneration of cells by glibenclamide was observed. The comparable regeneration was also shown by methanolic extracts of *B. diffusa* (Bhatia et al., 2001). A study was carried out to investigate the effects of daily oral administration of aqueous solution of *B. diffusa* L. leaf extract (BLET) (200 mg/kg) for 4 weeks on blood glucose concentration and hepatic enzymes in normal and alloxan induced diabetic rats. A significant decrease in blood glucose and significant increase in plasma insulin levels were observed in normal and diabetic rats treated with BLET (Pari and Satheesh, 2004). Chloroform extract of *B. diffusa* leaf produced dose-dependent reduction in blood glucose in streptozotocin-induced non-insulin-dependent diabetes mellitus (NIDDM) rats comparable to that of glibenclamide. The results specify that the reduction in blood glucose produced by the extract is possibly through renewal of pancreatic betacells or through extra pancreatic action (Nalamolu et al., 2004).

**Antibacterial activity**

A strong antibacterial activity against gram positive and gram negative bacteria shown by the leaves of *B. diffusa* might be due to the phytochemicals present in the leaves. Ethanol extract exhibited inhibitory effect on gram positive bacteria like *Staphylococcus aureus*, *Bacillus subtilis*, *Enterococcus faecalis*, *Micrococcus luteus* and all gram-negative bacteria selected for the present study. Methanol extract showed inhibitory effect against all gram-positive bacteria selected for the present study except *M. luteus* and gram-negative bacteria like *Klebsiella pneumoniae*, *Proteus vulgaris*, *Serratia marcescens* and *Shigella flexneri* (Sharma et al., 2008). The aqueous and ethanolic extracts of *B. diffusa* leaves had action on *Escherichia coli*, *S. aureus* and *Pseudomonas aeruginosa*. This activity occurred at varying concentrations, indicating that the plant extracts contain active principle with wide antibacterial spectrum. *E. coli* displayed the highest susceptibility to ethanolic extract, followed by *S. aureus* and the least susceptible
was *P. aeruginosa*. In aqueous extract, *P. aeruginosa* showed the highest susceptibility, followed by *S. aureus* and *E. coli* exhibits the least receptiveness. The antimicrobial action of the different extracts increased with increase in concentration (Velmurugan et al., 2010; Sandhya et al., 2011).

**Antistress/ adoptogenic/ immunomodulatory activity**

Hydroethanolic extract (80%) of *B. diffusa* (HEBD) and a polyherbal formulation (Punarnava mandur) PHF-09 containing *B. diffusa* were compared for their antistress activity using cold restraint stress model. Stress was induced by subjecting animals to cold restraint. Due to cold restraint stress there was an imbalance in the levels of biochemical parameters like glucose, triglycerides, cholesterol, glutamic-oxalacetic transaminase (SGOT), glutamic-pyruvic transaminase (SGPT) activity which were near normalized following the administration of HEBD and PHF-09. HEBD and PHF-09 were found to have similar anti-stress activity (Akinibosun et al., 2009). The ethanol extract of roots of *B. diffusa* was evaluated for antistress, adoptogenic activity in albino mice by swim durability test and cold restrains stress and the extract showed improved stress tolerance and immunomodulatory activity was observed in the form of increased carbon clearance, indicating stimulation of the reticuloendothelial system. There was a rise in DTH response to SRBC in mice, corresponding to cell mediated immunity and indicating stimulatory effects on lymphocytes and accessory cell types (Meera and Mustafa, 2007). *B. diffusa* (PUNARNAVA) has the ability to support both adrenal over and under activation. In stressful conditions, it has demonstrated the ability to safeguard against the elevations of serum cortisol and avoid the suppression of the immune system that takes place with raised cortisol. On the other hand, *B. diffusa* has also exhibited the ability to improve cortisol levels with end stage adrenal exhaustion (Mungantiwar et al., 1997).

**Hepatoprotective activity**

The hepatoprotective activity of roots of different diameters were collected in three seasons, rainy, summer and winter, and examined in thioacetamide intoxicated rats. The results showed that an aqueous extract (2 ml/kg) of roots of diameter 1 to 3 cm, collected in the month of May (summer), exhibited marked protection and majority of the altered serum parameters, that is, glutamic oxaloacetic transaminase (GOT), glutamic-pyruvic transaminase (GPT), acid phosphatase (ACP) and alkaline phosphatase (ALP), activity but not GLDH and bilirubin, thereby signifying the proper size and time of collection of *B. diffusa* L. roots for the most wanted results. Further, the studies also proved that the aqueous form of drug (2 ml/kg) administration has more hepatoprotective activity than the powder form; this is perhaps due to the better absorption of the liquid form through the intestinal tract. The hepatoprotective activity of *B. diffusa* L. roots showed noticeable protection of serum parameters in thioacetamide toxicity in rats. Additionally, the aqueous extract of thin roots collected in the summer has more activity, suggesting the proper time and type of root collection for the most desirable result. The assessment also confirms the use of *B. diffusa* L. roots in hepatic illnesses by the several tribes in India (Rawat et al., 1997). An alcoholic extract of whole plant *B. diffusa* given orally exhibited hepatoprotective activity against experimentally induced carbon tetrachloride hepatotoxicity in rats and mice. The extract also produced an increase in normal bile flow in rats, signifying a strong choleretic activity. The extract does not show any signs of toxicity up to an oral dose of 2 g/kg in mice (Chandan et al., 1991).

**Analgesic/anti-Inflammatory activity**

The decoction (DE) or juice (JE) of the leaves of *B. diffusa* was used to study the antinociceptive effect in chemical (acetic acid) and thermal (hot plate) models of hyperalgesia in mice. The DE raised the pain thresholds during the first period (30 min) of observation. In the acetic acid-induced abdominal writhing in mice, pre-treatment of the animals with naloxone (5 g/kg, i.p.) significantly reversed the analgesic effect of morphine and JE but not that of DE. The study proves that the active antinociceptive principle of *B. diffusa* is present mainly in the juice of fresh leaves and has a significant antinociceptive effect when assessed in these pain models (Hiruma et al., 2000). Ethanol extract of leaves at dose of 400 mg/kg exhibited maximum anti-inflammatory effect with 30.4, 32.2, 33.9 and 32% with carrageenin, serotonin, histamine and dextran induced rat paw edema models, respectively. Ethanol extract of stem bark also showed COX-1 inhibitory activity with an IC$_{50}$ value of 100 ng/ml, proving the drug use in the treatment of inflammatory condition. Anti-inflammatory activity was measured using extract of latex of plant by using a carragenan induced inflammatory model (Krishna et al., 2010).

**Antitumor activity**

Cancer chemo preventive property of *B. diffusa* was assessed on 7,12-dimethyl benz (a) anthracene (DMBA) induced skin papillomagenesis in male Swiss albino mice (6 to 7 weeks old). The cancer chemopreventive efficacy
was assessed by its ability to lessen the activities of enzymes associated with drug metabolism and bifunctional modulators reduced the availability of final carcinogen metabolites in the epithelial stage. A significant increase in the activities of hepatic phase I, phase II system enzymes and antioxidant enzymes (glutathione peroxidase, glutathione reductase, superoxide dismutase, catalase and glutathione level) were observed when mice were fed by oral gavage with B. diffusa extract at a dose level of 125 mg and 250 mg/kg body weight for a period of 14 days. It was inferred that the inhibition of tumorigenesis by the plant extract might have been due to preventing the formation of active carcinogens from their precursors or by augmenting detoxification process, preventing promotional events in the mouse skin through free radical scavenging mechanism (Rupjyoti et al., 2003).

**Anti-convulsant activity**

A study was carried out to investigate the methanolic root extract of B. diffusa and its different fractions including liriodendrin-rich fraction for discovering the possible role of liriodendrin in its anti-convulsant activity. Air-dried roots of B. diffusa were extracted with methanol by cold maceration. The methanol soluble fraction of extract thus obtained was continually extracted to obtain liriodendrin rich fraction and two side fractions, that is, chloroform fraction and phenolic compound fraction. Anticonvulsant activity of methanolic extract and its different fractions, that is, liriodendrin-rich fraction and phenolic compound fraction were studied in pentylenetetrazol (PTZ)-induced seizures. The crude methanolic extract of B. diffusa and only its liriodendrin-rich fraction showed a dose-dependent protection against PTZ-induced convulsions. The liriodendrin rich fraction showed significant protection against seizures induced by BAY k-8644. These findings reported the anticonvulsant activity of methanolic extract of B. diffusa roots and also it can be suggested that the observed anticonvulsant activity was due to its calcium channel antagonistic action as this activity was observed only in the liriodendrin-rich fraction which has furthermore been established by significant anticonvulsant activity of liriodendrin-rich fraction in BAY k-8644-induced seizures (Mandeep and Rajesh, 2011). Study showed that the crude methanolic extract of B. diffusa and its liriodendrin-rich fraction showed a dose-dependent protection against PTZ-induced convulsions (Adesina, 1979).

**Antiproliferative and antiestrogenic activity**

This describes the antiproliferative and antiestrogenic properties of methanol extract of B. diffusa (BME) in MCF-7 breast cancer cell lines. B. diffusa extracts exhibited a strong inhibitory effect on the production of human breast cancer cells in vitro and the antiestrogenic effects are mediated by ER. Phytochemical studies revealed the presence of alkaloids, flavonoids, phenols and saponins in BME. The antiestrogenic activity shown by the extract may be recognized to these diverse compounds (Sreeja and Sreeja, 1923).

**Cytological activity**

The extract of B. diffusa exhibited a strong depressive effect on the mitosis of Crinum jagus roots. The study was conducted using B. diffusa extract, the mitotic index of the control group was found to be 5.27. There was a negative association between the concentrations of the treatment extracts and the mitotic indices obtained from their action. This points to an inhibition of mitosis by this extract. Inhibition of the mitotic index increased significantly with an increase in the concentration of treatment solution of B. diffusa. Due to the ability of the root extracts of B. diffusa to collect metaphase and hence inhibit mitosis, it is possible to use these extracts as an alternative to the rather expensive colchicine for cytological studies (Ndubuisi et al., 2010).

**Bronchial asthma**

Dried leaves of B. diffusa can be used in dhoomapana in treatment of bronchial asthma. The leaf decoction is said to be an outstanding cough medicine when decocted with B. diffusa and then combined with ginger juice and black pepper (Sasi et al., 2009).

**Anti fibrinolytic activity**

A study evaluated the effect of antifibrinolytic agents; _-aminocaproic acid (_-ACA), tranexamic acid (AMCA); anti-inflammatory drugs (indomethacin, ibuprofen, naproxen) and plant extract (root extract of B. diffusa) on endometrial histology of inter uterine device (IUD)-fitted menstruating monkeys. It is effective in reducing stromal edema, inflammation, and tortuosity of glands, and in increasing the degree of deposition of fibrin and platelets in the vessel lumen (Barthwal and Srivastava, 1990).

**Antioxidant activity**

The assessment of the antioxidant potential of ethanolic extract of Andrographis echioides and B. diffusa was carried out by determining the levels of enzymatic and non-enzymatic antioxidants. The results showed that both the plant extracts possessed significant levels of enzymatic and non-enzymatic antioxidants. The results of the
enzymatic and non-enzymatic antioxidants in A. echinoides and B. diffusa exhibits that they possess preventive and productive role to maintain the cell survival, cellular interaction and maintenance of cell membrane architecture. A. echinoides and B. diffusa have effective and therapeutic antioxidant potential against various inflammatory diseases (Premkumar et al., 2010).

The study was undertaken to evaluate antioxidant activity of chloroform, ethanol, and ethyl acetate fraction of B. diffusa L. roots which might have improved its heaptoprotective action. In in vitro nitric oxide scavenging activity, the percentage inhibition was 71.35, 33.74, 23.85% in ethanol, chloroform and ethyl acetate extracts at 250 μg/ml when compared with curcumin which at 62 mcg/ml showed 84.7% inhibition, respectively. The ethanol extract and ethyl acetate showed a biphasic response whereas the chloroform extract showed a dose dependent increase. In DPPH radial scavenging activity, the ethanol extract showed 81.94% inhibition and the chloroform extract showed 42.58% inhibition at 100 mcg/ml compared with 88.02% inhibition by quercetin. The above results suggest that roots of B. Diffusa were found to show antioxidant potential which supports the use of this plant in traditional medicine (Gopal et al., 2010).

**Antiviral activity**

Recently, strong antiviral effectiveness of this plant has been observed against phytopathogenic viruses. The antiviral agent isolated from this plant was found to be a glycoprotein with a molecular weight of 16 to 20 kDa. Administered by foliar spraying in the field, this antiviral agent could protect some economically important crops against natural infection by plant viruses. The aqueous extracts of plant material were prepared and tested in vitro as well as in vivo against phytopathogenic viruses on their hypersensitive and systemic hosts. The botanical identity of each plant was established before the extracts were prepared. Of the large number of plants screened, B. diffusa root extracts were found to have a broad spectrum and very high antiviral activity (Awasthi and Verma, 2006).

**NUTRITIONAL VALUE**

Different concentrations of vitamins are found in 100 g of dry plant that is, vitamin C = 44.80 mg, vitamin B3 = 97 mg and vitamin B2 = 22 mg. Mineral content per 100 g includes sodium 162.50 mg, magnesium 8.68 mg and iodine 0.002 mg (Kokate et al., 2005). 15 amino acids such as aspartic acid, proline, methionine, leucine, phenylalanine, glycine, serine, threonine, arginine, alanine, asparagine, valine, tyrosine and tryptophane are also present (Anonymous, 1999).

**COMPOSITION OF LEAF OF B. DIFFUSA**

The composition of leaf of B. diffusa is shown in Table 1 (Ujowundu et al., 2008).

**CONSTITUENTS OF PHARMACOLOGICAL IMPORTANCE**

Phytochemicals are natural bio-active compounds present in fruits, vegetables, plants and flowers. Leaves and fibers also play very important role in body defense system against diseases or more accurately protect plants against diseases (Krishnaiah et al., 2009). The therapeutic potentials including anti microbial, anti oxidant, anti cancer properties of higher plants are due to secondary metabolites (Canigualeral et al., 2008; Kaur and Arora, 2009). Among very important bio active for example, flavonoids, alkaloids, glycosides and terpenoids. B. diffusa also contains a large number of flavonoids, retinoids, terpenoids, steroids, alkaloids (Kadota et al., 1989; Jain and Khana, 1989; Lami et al., 1990, 1991a). These biologically active compounds known as secondary metabolites in medicinal plants, form the foundations of modern prescription drugs (Sowora, 1993).

It was discovered that multiple constituents are responsible for therapeutic effects of plant. These constituents act as a whole and it is very difficult to separate them as single. Moreover phytoconstituents in herbs mostly depend on plant origin, harvest season, time of cultivation, drying processes and other factors (Walker, 2004). First screening of B. diffusa revealed that it contains sterols (Singh and Udupa, 1972), β-sisitosterol (Srivastava et al., 1972; Desai et al., 1973) and alkaloids. It contains about 0.04% of alkaloid known as punarnavine {C17 H22N2 O, mp (236 to 237°C)} (Surange and Pendse, 1972b) and punarnavoside, an anti fibrinolytic agent. Ursolic acid was also found in plant (Kokate et al., 1991a).

**Table 1.** The composition of leaf of B. diffusa.

<table>
<thead>
<tr>
<th>Leaf composition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>82.20</td>
</tr>
<tr>
<td>Protein</td>
<td>6.06</td>
</tr>
<tr>
<td>Fats</td>
<td>0.90</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>7.20</td>
</tr>
<tr>
<td>Ash</td>
<td>0.96</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.67</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.99</td>
</tr>
<tr>
<td>Fiber</td>
<td>0.56</td>
</tr>
</tbody>
</table>
Research has demonstrated the presence of alkaloids and amino acids in B. diffusa (Garg, 1978, 1980). Two known lignans, liriodendrin and syringaresinol mono-b-D-glucoside, have been isolated from a methanol extract of the roots of B. diffusa and the former compound was found to exhibit a significant calcium channel antagonistic effect (Lami et al., 1991). The seeds of this plant contain fatty acid and allantois and the roots contain alkaloid (Aslam, 1996). The green stalk of the plant has also been reported to contain boehavain and boerhavic acid (Liogier, 1990). Hentriacontane, β-sitosterol, ursolic acid along with some kinds of sugars were isolated from roots of B. diffusa (Misra and Tiwari, 1971). New C-methyl flavones characterized as 5, 7- dihydroxy-6-8-dimethoxy flavones have been reported from root (Gupta and Ahmed, 1984) and designated as boerhavone (Ahmed and YU, 1992). Many retinoid have been separated from roots of plant (Kadota et al., 1989; Lanni et al., 1990, 1991b). These include a series of boeravinone A, boeravinone B, boeravinone C, boeravinone D, boeravinone E, boeravinone F, boeravinone G, boeravinone H (Figure 1).

Punarnavoside is present in roots and characterized as 2-glucopyranosyl-6'-hydroxy-1-(p-hydroxyphenyl) propionyl diphenyl methane (Seth et al., 1986; Jain and Khana, 1989). Alcoholic extracts of B. diffusa leaves has immunosuppressive properties (Pandey et al., 2005). A new dihydroisofuraxaanthone, methyl 3-10-dihydro-11-hydroxy-1-methoxy-4-6-dimethyl-10-oxo-1H-furo [3, 4-b] xanthenes-3-corboxylate, designated as boerhavine has been extracted from benzene extract of roots of B. diffusa (Ahmed and YU, 1992). Various compounds like phenols, terpenes and volatile constituents were identified by using headspace–solid phase microextraction–gas chromatography–tandem mass spectrometry (HS-SPME-GS-MS). Moreover, numerous phenolic acids and flavonoids were also confirmed from study like quercetin and kaempferol (Pereira et al., 2009).

Two quinolized alkaloids were identified as Punarnavaine I and Punarnavaine II. Their distribution in
stems was maximum but minimum in roots. Content which is primarily low steadily increases during end of reproductive stage (Nandi and Chatterjee, 1974).

TOXICITY OF BOERHAVIA DIFFUSA

Toxicological studies done on B. diffusa confirmed the absence of teratogenic and mutagenic effects and ingestion of bigger doses is linked with nausea (Singh, 1991; Patwardhan et al., 2004)

EFFECT OF SEASONAL CHANGES AND ROOT THICKNESS ON HEPATOPROTECTIVE ACTIVITY OF PLANT EXTRACT

Hepatoprotective activity of plant is better in aqueous form (2 ml/kg) than powdered form which shows that the aqueous form of drug administration is better. Undoubtedly, it might be due to the improved absorption of the liquid form of the drug from the intestinal tract. On the other hand, high levels of serum marker hepatic enzymes were significantly reduced by the thin root extract (aqueous) of B. diffusa L. as compared to thick roots, signifying that the drug resultant from the thin roots has more hepatoprotective effect. Moreover, differences in hepatoprotective activity linked with adjustment in seasons. Protection of the common serum marker hepatic enzymes is greater in summers, as equated to the other, recommending it to be an appropriate time for gathering of the herb (Rawat et al., 1997).

CONCLUSION

The plant in whole or its uncommon parts (aerial parts and roots) have plentiful medicinal properties and are used in widespread manner by ethnic people. The investigated and reported pharmacological and therapeutic properties of B. diffusa are; laxative, immunomodulatory activities, cancer chemo-preventive efficacy, anti-inflammatory, inhibition of tumor genesis, antioxidant activity, genoprotective, hepatoprotective activity, spleenomegaly, hypoglycemic activity, antifungal, anti-proliferative, anti-estrogenic, morphinomimetic central analgesic property, potent anti-fibrinolytic, antibacterial activity, anticonvulsant activity, diuretic, spasmyloytic activity, antinociceptive, anti-stress and dyspepsia. Boerhaavia species has been studied with deep interest due to its promising medicinal values in phytochemical and pharmacological research field. The objectives of review on B. diffusa is to sum up plant morphology, chemical compositions, its ethno-medicinal uses, linked from ancient times to the present, with a scope of development in future and this will be supportive to ascertain a standard a standard likely drug for auxiliary exploration. The various benefits of B. diffusa made it a true wonder of nature.

REFERENCES

Hiruma ICA, Gracioso JS, Bighetti EJ, Germonse RL, Souza BAR


