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Boerhaavia Diffusa Linn Plant: A Review – One Plant with Many Therapeutic Uses

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Abstract

Today's world is full of huge numbers of different diseases because of our hasty schedule, and to treatment of those diseases, a huge number of medicines are taken every day to control and cure those diseases. Therefore, willingly or unwillingly, we are required to accumulate a large amount of chemicals which are lethal and unsafe for our body. Consequently, these stored chemicals produce another disease in our body, and to alleviate it, another medicine is needed which adds up more poisonous chemicals which were previously stored in our body. For this reason, the uses of natural or herbal medicines are increasing day by day due to their biodegradable nature. *Boerhaavia diffusa* commonly known as punarnava is a perennial herbaceous plant belonging to family Nyctaginaceae widely studied and has a long history of therapeutic uses by the indigenous and tribal people and also in Ayurvedic and Unani medicines. The chemical presents in the whole plant of *Boerhaavia diffusa* L. which makes it as outstandingly useful plant is now been traced out. Now, it is regarded as anti-inflammatory, antioxidant, antiaging, anticancerous, antibacterial, antistress, hepatoprotective and antidiabetic compound. Its biological used as a kidney and heart tonic and also to treat general fever, jaundice, obesity, asthma and to kill intestinal worms. The present paper provides a detailed account of therapeutic uses of whole plant of *Boerhaavia diffusa* linn. In this review, we will try to discuss the multifunctional uses of the plant and also we will try to summarize the innovative research on this plant.

Keywords: *Boerhaavia diffusa* L., Phytochemicals, Pharmacological properties, Ethanobotanical uses, Diseases, Ayurveda.



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INTRODUCTION

There are different types of herbs useful for the prevention of the diseases that affect the various organs in the animals as well as human beings. The herbs are the initial steps for the advancement of the bioactive molecules of the drugs and its developments. The property of herbs is that it is not contain the useful contain there are harmful contain also having in the herbs. Indigenous plants are the natural inhabitants, as they are naturally occurring plants. It's essential to save indigenous species because they have often evolved to cope up with some conditions and circumstances. Indigenous species found to contain unique properties, which have been used to develop specialized drugs to save lives. It is noticeable that numerous vital herbal drugs have been developed based on ancient folk healers for treatment of ailments. Moreover, plants are the foremost line of defense for treatment of several illnesses. ^[1-6]

Presently, traditional herbal medicines are getting noteworthy attention in global health debate. Traditional medicines are the knowledgeable tool for the various practices as well as skills. These are based on the various theories, principles several benefits as well as their experiences related to their culture that is used for the health maintains as well as cure, diagnosis treatment, improvement, and also used for the treatment of physical and mental problems. The medicine that is traditional has been accepted by the population for the term is alternative medicine. The examples of the herbal medicines are the herbal preparations as well as herbal materials or finished products that are the part of the active portion of the plants. ^[7-16]

Boerhaavia diffusa is the most important herb for the life, commonly known as Punarnava in Sanskrit, is an herbaceous plant of the family Nyctaginaceae. The whole plant of *Boerhaavia diffusa* and its specific parts i.e. leaves, stem, and roots are known to have medicinal properties and have a long history of traditional use by indigenous and tribal people in India and is used throughout India. The curative value of *Boerhaavia diffusa* linn or punarnava in the management of a various number of clinical diseases is proved in Charaka Samhita, Sushruta Samhita and Ayurveda. *Boerhaavia diffusa* linn has several ethanobotanical uses such as the leaves are used as vegetable and the roots juice is used to cure asthma, urinary disorders, leukorrhea, rheumatism, and encephalitis. *Boerhaavia diffusa* is a chief medicinal plant of Kumaun Himalaya, have different pharmacological activities and used as a medicine in Ayurvedic, Unani, Siddha and Homoeopathy Systems. *Boerhaavia diffusa* plant was named in honor of Hermann Boerhaave, a well-known Dutch physician of the 18th century. The plant of *Boerhaavia diffusa* is mentioned in the Atharvaveda with the name 'Punarnava', because the top of the plant dries up for the period of the summer season and regenerates again during the rainy season. It is called as Punarnava (Punar + nava) because of Punar means - once again, Nava means - becoming new. This is also known as spiderlings as this plant grows low and spreads like spider. ^[17-25]



Figure No.1: Representation Photograph of *Boerhaavia diffusa* leaves and roots.

Taxonomical Classification: -

Kingdom:	Plantae
Subkingdom:	Tracheobionta
Superdivision:	Spermatophyta
Division:	Magnoliophyta
Class:	Magnoliopsida
Subclass:	Caryophyllidae
Order:	Caryophyllales
Family:	Nyctaginaceae
Genus:	Boerhaavia L.
Species:	Boerhaavia diffusa L.

Scientific Name: *Boerhaavia diffusa* Linn.

Family Name: Hog weed, Horse Purslane.

Useful Parts: Roots, leaves and seeds.

Names in Different Languages (Vernacular Name): -

Sanskrit: Kahtilla, Sophaghni, Varshabhu, Punarnava, Raktakanda, Shothaghni,

Hindi: Gadahpurna, Lalpunarnava, Snathikari, Biskhafra, Beshakapori

Bengali: Raktapunarnava, Punurnava

English: Horse Purslane, spreading Hog - Weed

Assamese: RangaPunarnabha

Gujrati: Dholisaturdi, Motosatodo

Kannada: Sanadika, Kommeberu, Komma, Kommegida



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Kashmiri: VanjulaPunarnava

Malayalam: ChuvannaTazhutawa

Marathi: Ghetuli, Vasuchimuli, Satodimula, Punarnava, Khaparkhuti, Tambadivasu

Oriya: Lalapuiruni, Nalipuruni

Punjabi: Khattan

Tamil: Mukurattai (Shihappu)

Telugu: Atikamamidi, Erragalijeru, Punernava. ^[17-25]

Geographical Distribution and Habitat:

Boerhaavia diffusa (Nyctaginaceae) plant is a perennial species growing prostrate or ascending upward in habitats such as grasslands, agricultural fields, fallow lands, wastelands, residential compounds, ditches and marshy places during rains. *Boerhaavia diffusa* plant is consisting of 40 species is distributed in tropical and subtropical regions and warm climate. It is found in Pakistan, Ceylon, Australia, Sudan and Malay Peninsula, extending to China, Africa, America and Islands of the Pacific that is found in warmer parts of these countries. 6 species of *Boerhaavia diffusa* plant are found in India, namely *Boerhaavia diffusa*, *B. erecta*, *B. rependa*, *B. chinensis*, *B. hirsute* and *B. rubicunda* in warmer parts and all over up to 2,000 m altitude in the Himalayan area. The plant is also cultivated to some extent in West Bengal. ^[17-25]

Macroscopic Characters: -

Stems: Stems of *Boerhaavia diffusa* are greenish purple, stiff, slender, cylindrical and swollen at nodes or thick at the nodes, minutely pubescent or nearly glabrous. They are prostrate divaricately branched; branches from common stalk about 1 m in length. Stems are pale greenish below and light reddish brown above.

Roots: Roots of *Boerhaavia diffusa* are elongated, fusiform, tapering and somewhat tuberous or somewhat tortuous, cylindrical, 0.2–1.5 cm in diameter, surface soft to touch but rough due to minute longitudinal striations and root scars, fracture, short. Roots of *Boerhaavia diffusa* grow up vertically downwards striking deep into the soil. Old roots are often marked with knotty scars of fallen rootlets. Roots have no distinct odor; taste is slightly bitter, sweet, and pungent. They are cream or light brownish yellow, with very soft skin. ^[22-26]

Leaves: Leaves of *Boerhaavia diffusa* are contradictory in unequal pairs, ovate-oblong or sub orbicular, apex rounded or slightly pointed, base subcordate or rounded. Leaves size is larger ones 25– 37 mm long and smaller ones 12–18 mm long and colour is green and whitish below, glabrous above. Margin entire or sub undulates, dorsal side pinkish in certain cases, thick in texture, petioles nearly as long as the blade, slender.

Flowers: Flowers of *Boerhaavia diffusa* are very small, lower part greenish, ovoid and upper part pink in colored, funnel-shaped, nearly sessile or shortly stalked, 10–25 cm, in small umbells, arranged on slender long stalks, 4–10 corymb, axillary and in terminal panicles, small, acute, bracteoles, perianth tube. Flowers are



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internally sessile in small umbels, about 10 - 25 mm in length. Fruits are one seeded nut, glandular, rounded and about 0.5 cm in size that is 6 mm long clavate, broadly and straightforwardly 5 ribbed. ^[26-30]

Whole plant of *boerhaavia diffusa* is devoid of fragrance and taste is bitter.

Microscopic Structures: -

Stem: *Boerhaavia diffusa* stem that is transverse section of stem illustrates epidermal layer containing uniseriate glandular trichomes and multicellular which consists of an ellipsoidal head and 9-12 stalked cells, 150–220 µm long cortex that is consists of 1–2 layers of parenchyma, endodermis indistinct, pericycle 1–2 layered and thick-walled often containing scattered isolated fibers, stele which is consisting of various small vascular bundles frequently joined simultaneously in a ring and various large vascular bundles scattered in the ground tissue, and intrafascicular cambium present.

Root: Transverse section of *boerhaavia diffusa* linn root illustrates a cork composed of thin-walled agilely elongated cells with brown walls in the outer few layers and cork cambium of 1–2 layers of thin-walled cells. Secondary cortex consists of 2–3 layers of parenchymatous cells followed by cortex composed of 5–12 layers of thin-walled, oval-to-polygonal cells and several concentric bands of xylem tissue alternating with wide zone of parenchymatous tissue present below cortical regions and number of bands vary according to the thickness of root of *Boerhaavia diffusa* and composed of vessels, tracheids, and fibers. Vessels generally originate in clusters of 2–8 in radial rows, containing reticulate thickening, small, thick walled, tracheids and simple pits. Fiber saseptate, thick-walled, spindle shaped and elongated with pointed ends. Phloem takes place as hemispherical outer surface each group of xylem vessels and created of sieve elements and parenchyma, broad zone of parenchymatous tissue. Two successive rings of xylem elements arranged of thin-walled additional or fewer rectangular cells organized in radial rows, central areas of root of *Boerhaavia diffusa* occupied by main vascular bundles, many raphides of calcium oxalate in single or in group present in cortical section. Parenchymatous tissue in between xylem tissue and simple starch grains, compound containing 2–4 components originate in abundance in most of cells of cortex.

Leaves: Transverse section of *Boerhaavia diffusa* leaf illustrates anomocytic stomata on both the sides, several, a few short hairs, 3–4 celled that is present on the margin and on veins, palisade one layered, spongy parenchyma 2–4 layered among tiny air spaces. Idioblasts having raphides intermittently cluster crystal of calcium oxalate and orange-red resinous substance present in mesophyll. Palisade ratio 3.5–6.5, stomatal index 11–16, and vein islet number 9–15. ^[26-30]

Phytochemistry: Phytochemicals are natural bioactive compounds found in plants, including the medicinal plants, fruits, vegetables, flowers, leaves, roots and fibers and they act as a defense system against diseases or more accurately protect plants against diseases. The therapeutic abilities, including antioxidant property, antimicrobial and anticarcinogenic properties of higher plants are due to the occurrence of secondary metabolites like flavonoids etc. The medicinal values of these plants lie in bioactive phytochemical constituents



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with the intention of produce exact physiological actions on the human and animal body. A number of the most significant bioactive phytochemical constituents are the alkaloids, glycosides, carbohydrates, flavonoids, essential oils, tannins, steroids, terpenoids and phenolic compounds. These biologically active chemical constituents recognized as secondary metabolites in medicinal plants, form the establishments of modern prescription drugs. In recent decades, there are many reports on the use of medicinal plants. From the previous studies, it was find out that the accurate amount of active chemical constituent are frequently unidentified. Therefore, it was discovered that multiple chemical constituents are generally responsible for the therapeutic effects of the plants. These multiple chemical constituents may take action synergistically and can hardly be divided into active parts. Furthermore, the herbal chemical constituents may be different depending on the harvest seasons, plant origins, drying procedure and other aspects.

The *Boerhaavia diffusa* linn contains a huge number of such chemical constituents as alkaloids, steroids, triterpenoids, lipids, flavonoids, lignins, carbohydrates, proteins, and glycoproteins. Punarnava also have been isolated such chemical constituents including Boeravinone A-F, hypoxanthine 9-Larabinofuranoside, ursolic acid, punarnavoside, lirodendrin, and a glycoprotein having a molecular weight of 16– 20 kDa, considered in detail for their biological activity. Punarnavine $C_{17}H_{22}N_2O$ m. p. 236–237°C. *Boerhaavia diffusa* linn also contains 2- α -sitosterol, palmitic acid, arachidic acid, β -Sitosterol, ester of β -sitosterol, hexacosonoic, stearic, tetracosanoic, urosilic acid, β -Ecdysone, triacontanol, Hentriacontane etc. The herb and roots of punarnava are rich in proteins and fats. The herb contains 15 amino acids, with 6 essential amino acids, whereas the root contains 14 amino acids, as well as 7 essential amino acids. Plant contained large quantities of potassium nitrate, besides punarnavine. ^[17-30]

Chemical constituents of Root: -

The root contains 14 amino acids, including 7 essential amino acids (total 11.54 %). These are: alanine 1.18; arginine 0.75; aspartic acid 0.95; glutamic acid 1.45; leucine 0.88; methionine 0.45; ornithine 0.96; phenylalanine 0.71; proline 0.5; serine 0.85; threonine 0.79; tryptophan 0.65; tyrosine 0.72; asparagines 0.0; glycine 0.0 and valine 0.75 %²⁹. The root of *Boerhaavia diffusa* linn was reported to yield a new dihydrofuranoxanthone and c-methyl flavone designated as borhavine and borhavone respectively. Other four new compounds have been isolated as boerhavisterol, boerhavanostenyl benzoate, boerhadiffusene, diffusarotenoid and a known rotenoid, boeravinone were also isolated from its roots. Roots presented fewer flavonoid derivatives quercetin-3-O-robinobioside and eupalitin-3-O-galactosyl (1-2)-glucoside, but exhibited one phenolic acid, caffeoyltartaric acid, which was absent in leaves. ^[17-30]

Table 1: Chemical constituents isolated from different parts of *Boerhaavia diffusa* linn.

Chemical classes	Name of compounds	Activity reported	Plant parts
Phenolic glycoside	Punarnavoside	Antifibrinolytic	Roots
C-Methyl flavone	Borhaavone		
Isoflavone	2-O-Methyl abronisoflavone		
Isoflavone	Quercetin, kaempferol	Antifibrinolytic	Leaves
Acids	Tetracosanoic, hexacosanoic, stearic, palmitic, arachidic acids. Boerhavin and boerhaavic acid.		
Flavonoid Glycoside	3,4-Dihydroxy-5-methoxycinnamoyl rhamnoside, Quercetin 3-O-rhamnosyl (1→6), galactoside (quercetin 3-O-robinobioside), Eupalitin 3-O-galactosyl (1→2) glucoside, Kaempferol 3-O-robinobioside, Eupalitin-3-O-β-D-galactopyranoside.		
Phenolic acid	<i>Trans</i> -caftaric acid	Antifibrinolytic	Roots
Rotenoids	Boeravinones A, B, C, D, E, F. Boeravinones G, H. Boeravinones I, J.		
	9-O-Methyl-10-hydroxy coccineone E. Diffusarotenoid.		
	6-O-Demethyl-boeravinone H. 10-Demethyl boeravinone C. Coccineones E, B. Boeravinones M, P, Q, R, S.	Spasmolytic	Roots
Xanthone	Boerhavine	Spasmolytic	Roots
Lignan	Liriodendrin, Syringaresinol mono-β-D-glucoside.	Ca ²⁺ channel antagonist	Roots
Purine nucleoside	Hypoxanthine-9-L-arabinofuranoside	Cardiotonic	Roots
Sterol	Boerhavisterol	Cardiotonic	Roots



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Sterol ester	Boerhavanostenyl benzoate	Cardiotonic	Roots
Ecdysteroid	β -Ecdysone	Increases protein synthesis, antidepressant, antistress and immunomodulation, antihyperglycemic, hepatoprotective	Roots
Fatty acid	Triacont-24-en-1-oic acid		
Hydrocarbons	Boerhadiffusene		
Lipids	5-methyleicos-4-ene, Eicos-4-ene, 4-methyloctadec-3-ene, 4-methylnonadecylbenzene.		

Adulterants and Substitutes: *Boerhaavia diffusa* Linn (Raktapunarnava) are frequently adulterated with *Trianthema portulacastrum* Linn which is market samples. The two different Ayurvedic drugs punarnava and Varshabhu possibly that are the two different plant sources with similar therapeutic effects. The two species differ widely in their stomatal indices and palisade ratios, *Trianthema portulacastrum* possessing higher values. [17-20]

Ethanobotanical uses: - *Boerhaavia diffusa* is a very popular medicinal plant In India, known as 'Punarnava'; particularly plant parts as the leaves, seeds and roots are used. The root of *Boerhaavia diffusa* is registered in the Indian Pharmacopoeia. Plant parts of punarnava are used as a Stomach disorder, Reduces cough, cardio tonic, anasarca, hepatoprotective, ascites, laxative, diuretic, anthelmintic and febrifuge, healing power and curative properties, expectorant and as an emetic and purgative. As diuretic and natriuretic agents it is useful in treatment of diabetes insipidus, nephrolithiasis, strangury, Oliguria, jaundice, poisoning, enlarged spleen, glaucoma, gonorrhoea, congestive heart failure, Mountain sickness and other internal inflammations. In moderate doses it is successful in asthma. A decoction of the roots of punarnava is also useful to treat corneal ulcers and night blindness. The boiled roots of *Boerhaavia diffusa* Linn are useful to ulcers, abscesses and to aid in the extraction of Guinea worm in tropical Africa region. A decoction of the aerial parts is also used to manage gastrointestinal pains, convulsions, and intestinal worms. The seeds of punarnava are made into cakes that are cooked and eaten as a remedy for dysentery in Mauritania and also in west Bengal, *Boerhaavia diffusa* herb is cooked and eaten as a vegetable. A decoction of the root is also taken to treat heart troubles, palpitations and jaundice. Immunomodulatory Activity: Sumanth and coworker compared the effect of BD with ashwagandha and identify an increase in total swimming time in mice when fed with alcoholic extract. (Whitehouse, 1996; Mudgal, 1975; Shah et al., 1983; Jain and Khanna, 1989; Khare, 2004; Singh and Dey, 2005). Burkill, 1997; Neuwinger, 2000; Gupta et al., 1962; Gaitonde et al., 1974; Nadkarni, 1976; Anand, 1995; Mitra and Gupta,

1997; Database entry for Erva Tostao - Boerhaavia diffusa - htm;www.Rain-tree.com; www.allayurveda.com/herb; www. Protabase Record.htm).

Table 2: Ethno medical uses of *Boerhaavia Diffusa* linn by various countries.

Name of the Country	Ethno Medical Uses
Brazils	Used for kidney stones, beri-beri, gallstones, bile insufficiency, cystitis, laxative, edema, liver disorders, gallbladder problems, albuminuria, gonorrhoea, guinea worms, urinary disorders, hepatitis, hypertension, jaundice, nephritis, renal disorders, sclerosis, snakebite, spleen enlarged, urinary retention.
Guatemala	Used for erysipelas, guinea worms.
India	Used for urinary disorders, weakness, abdominal pain, impotence, anemia, ascites, asthma, blood purification, anasarca, hepatoprotective, cancer, cataracts, childbirth, laxative, cholera, constipation, cough, debility, as a wound healer, digestive sluggishness, dropsy (swelling in tissue), dyspepsia, edema, eye problems, fever, gonorrhoea, ascites, guinea worms, heart disease, hemorrhages (childbirth and thoracic), hemorrhoids, internal inflammation, internal parasites, jaundice, renal disease, renal stones, lactation relieve, hepatic disorders, liver support, menstrual disease, rheumatism, snakebite, splenomegaly and as a diuretic and expectorant.
Iran	Used for edema, poisoning, gonorrhoea, hives, intestinal gas, jaundice, joint pain, ascites, lumbago, glomerular nephritis, and as an appetite stimulant, anasarca, diuretic and expectorant.
Nigeria	Used for asthma, boils, renal insufficiency, convulsions, abscesses, epilepsy, fever, jaundice, guinea worms, and as an expectorant and laxative.
West Africa	Used for guinea worms, urinary disorders, menstrual irregularities, abortion and as an aphrodisiac.
Philippinese	Used for diuretic, fever, purgative and vermifuge.
Ghana	Used for asthma and Boils.
Elsewhere	Used for childbirth, guinea worms, jaundice, sterility, yaws.

Pharmacological 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



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activity, antimetastatic activity, antioxidant activity, antidiabetic activity antiproliferative and antiestrogenic activity, analgesic and anti-inflammatory activity, antibacterial activity, antistress and adoptogenic activity, antilympho proliferative activity, nitric oxide scavenging activity, hepatoprotective activity, anti-viral activity, bronchial asthma, anti fibrinolytic activity, chemopreventive action, genetic diversity analysis, anticonvulsant activity.^[31-52]

Antidiabetic activity: - This study was evaluated the effects of aqueous extract of *Boerhaavia diffusa* Linn leaves (200 mg/kg wt.) for 4 weeks daily oral administration on blood glucose concentration and hepatic enzymes in normal and alloxan induced diabetic albino wistar rats. Normal and diabetic rats treated with aqueous leaves extract of *Boerhaavia diffusa* Linn. were detected a significant reduce in blood glucose and significant enhance in plasma insulin levels. On the basis of previous study, Chloroform extract of *Boerhaavia diffusa* leaf produced dose-dependent decrease in blood glucose in streptozotocin- treatment for 48 h resulted in a significant enhance in the number of MCF-7 cells in the G0-G1 fraction from 69.1% to 75.8 %, with a reciprocal reduce of cells in all other phases indicating cell cycle detain at G0-G1 phase. Bhatia *et al.* (2011) has been evaluated the Antidiabetic Activity of the Alcoholic Extract of the Arial Part of *Boerhaavia diffusa* in Rats. This study showed that alcoholic extracts of *Boerhaavia diffusa* have good quality antidiabetic action in rats. Mohan Nisha *et al.* (2018) performed antidiabetic and antihyperlipidemic activities of whole plant of *Boerhaavia erecta* L. in STZ-induced type 2 diabetic Wistar rats. Krishna Murti *et al.* (2011) also evaluated the anti diabetic - activity of 90% ethanolic extract of *Boerhaavia diffusa* roots against streptozotocin (STZ) induced experimental rats. The aim of this study was evaluated the effects of daily oral administration of 90% Ethanolic solution of *Boerhaavia diffusa* Linn.^[31-32, 50]

Antibacterial Activity: - A potent antibacterial activity against Gram-positive and Gram-negative bacteria shown by the leaves of *Boerhaavia diffusa* might be due to the phytochemicals present in the leaves. Ethanol extract showed inhibitory an effect on Gram-positive bacteria such as *S. aureus*, *Bacillus subtilis*, *Streptococcus faecalis*, and *Micrococcus luteus* and all Gram-negative bacteria selected for the study. Umamaheswari *et al.* (2010) also studied the antibacterial activity of *Boerhaavia diffusa* L. leaves. The antimicrobial activity of *Boerhaavia diffusa* L. Leaves with different solvent extracts were tested against the Gram-positive and Gram-negative bacterial strains by detecting the zone of inhibition. The ethanol extract of *Boerhaavia diffusa* L. leaves showed more activity against Gram-positive and Gram-negative bacteria when compared to other solvent extracts except *V. cholerae*. The results proved the existence of antibacterial activity of *Boerhaavia diffusa* L. leaves extract against various human pathogenic bacteria.

Anti viral and antifungal activity: - Awasthi and Menzel (1986) reported that an extract obtained from the roots of *Boerhaavia diffusa* plants, inhibits the infection of several plant viruses and was tested by the agar diffusion whole method for its action on RNA-containing bacterial viruses. According to Rai and Upadhyay (1988) the leaf extract of *Boerhaavia diffusa* shows *in vitro* antifungal activity against *Microsporon nanumi*.^[33]



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Anti-stress Activity: - This study was investigated the effects of Hydro ethanolic extract of *Boerhaavia diffusa* linn and a polyherbal formulation (Punarnava mandur) PHF-09 containing *Boerhaavia diffusa* were compared for their anti-stress activity using cold restraint stress model. In subjecting animals, Stress was induced to cold restraint. Due to cold restraint stress, there was an imbalance in the levels of biochemical parameters such as glucose, triglycerides, cholesterol, SGOT, and SGPT which were near normalized following the administration of HEBD and PHF-09. *Boerhaavia diffusa* linn and a polyherbal formulation (Punarnava mandur) PHF-09 was found to have comparable significant anti-stress activity as reported in the study.

Diuretic activity: - Singh and coworkers studied the effect of aqueous ethanolic extract on *E. coli*-induced acute pyelonephritis in rats. The extract of *Boerhaavia diffusa* (50 mg/Kg p.o.) administered twice orally showed 42.85% decrease in quantity of animals and they showed signs of renal changes. Therefore, the administration of the extract of *Boerhaavia diffusa* (50 mg/Kg p.o.) twice orally showed 99.09% decrease in bacterial count per mL of urine in rats. Other researchers as Nadkarni and Chopra reported and described the diuretic activity and alkaloidal nature of punarnavine. Patel *et al.* (2020) also evaluated diuretic and natriuretic activity of ethanolic extract of *Boerhaavia diffusa* Linn root in Albino Wistar Rats. They found that ethanolic extract of *Boerhaavia diffusa* Linn roots has got significant potential to be utilized as a diuretic and natriuretic substances and it may be due to presence of chemical constituents such as amino acids and alkaloids etc.

Adaptogenic/Immunomodulatory Activity: - The ethanol extracts of the roots of *Boerhaavia diffusa* was evaluated for antistress, adaptogenic activity in albino mice, by swim endurance test and cold restraint stress, and the ethanolic roots extract improved stress tolerance in immunomodulatory activity that was shown by enhanced carbon clearance, signifying stimulation of the reticuloendothelial system. There was enhance in DTH response to SRBC in mice, subsequently to cell-mediated immunity and signifying stimulatory effects on lymphocytes and accomplice cell types. Therefore, the aqueous extract of *Boerhaavia diffusa* leaves showed immunomodulatory activities and antinociceptive effect of. According to previous study by Mehrotra *et al.* (2002) the ethanolic extract of *Boerhaavia diffusa* was capable to reduce T-cell mitogen phyto haemagglutinin and concanavalin a excited proliferation of human peripheral blood mononuclear cells (PBMC).

Antimicrobial activity: - Sourav Das *et al.* (2012) studied the Antimicrobial activity study of ethanolic extract of *Boerhaavia diffusa* whole plant. They investigated ethanolic extract of *Boerhaavia diffusa* whole plant in 95% ethanol possesses the significant antimicrobial activity. James Redfern *et al.* (2014) they also investigated the antimicrobial effects of plant material after extracting compounds using the relatively simple Soxhlet method and also studied Safety issues about The Soxhlet extraction process heats the solvent (ethanol) to boiling temperature (>78°C).

Hepatoprotective Activity: - The hepatoprotective activity of roots of different diameters was collected in three seasons, rainy, summer, and winter, and examined in thioacetamide-intoxicated rats. The roots *Boerhaavia diffusa* has long been utilized as a popular hepatoprotective medicine for therapeutic purpose. Various extracts



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of the aerial part and roots of this plant showed hepatoprotection against CCl₄. This plant extracts shows hepatoprotective and antioxidant activity in a dose dependent manner. Chandan, et al. (1991) evaluated that an alcoholic extract of the whole plant of *Boerhaavia diffusa* linn demonstrated hepatoprotective activity against experimentally induced carbon tetrachloride hepatotoxicity in rats and mice. The extract of *Boerhaavia diffusa* linn also produced enhances normal bile flow in rats signifying a strong choleric property. Singh et al. (1991) reported teratogenic effects by the ethanolic extract of *Boerhaavia diffusa* on litter size and survival rate of foetuses in rats. Jain *et al.* (2013) also studied Protective effect by extract of *Silybum marianum* and *Boerhaavia diffusa* in combination against fructose induced non-alcoholic fatty liver in rats. [35-36]

Antitumor Activity: - The Cancer chemopreventive efficacy of *Boerhaavia diffusa* was estimated on 7, 12 dimethyl benz (a) anthracene-induced skin papillomagenesis in male Swiss albino mice. The cancer chemopreventive effectiveness of *Boerhaavia diffusa* was evaluated through its capability to modulate the activities of enzymes correlated with drug metabolism, and bi functional modulators decreased the availability of critical carcinogen metabolites in the epithelial stage. A significant increase in the activities of hepatic phase I and phase II system enzymes and antioxidant enzymes (glutathione peroxidase, glutathione reductase, superoxide dismutase, catalase, and glutathione level) was observed. Mehrotra and coworkers studied the immunomodulation produced Anticancer Activity.

Anticonvulsant Activity: - Anticonvulsant activity of the methanolic extract and its different fractions, i.e., liriiodendron-rich fraction and phenolic compound fraction was studied in pentylenetetrazol Ghosh and Rai: Multifunctional effect of *Boerhaavia diffusa* induced seizures. The methanolic extract of crude powder of *Boerhaavia diffusa* and only its liriiodendron-rich portion proved a dose-dependent protection adjacent to PTZ-induced convulsions. The liriiodendron-rich fraction showed a significant protection against seizures induced by BAY k-8644. These findings reiterated the anticonvulsant activity of the methanolic extract of *Boerhaavia diffusa* roots, and also it can be concluded that the observed anticonvulsant activity was due to its calcium channel antagonistic action as this activity was determined only in the liriiodendron-rich fraction, that has additionally been proved by considerable anticonvulsant activity of liriiodendron-rich fraction in BAY k-8644-induced seizures. [30]

Antiproliferative and Antiestrogenic Activity: - The methanol extract of *Boerhaavia diffusa* revealed antiproliferative and antiestrogenic properties in MCF-7 breast cancer cell lines. The methanolic extract of *Boerhaavia diffusa* linn showed a strong inhibitory effect on the proliferation of human breast cancer cells in vitro, and the antiestrogenic effects are mediated by ER. Phytochemical studies of *Boerhaavia diffusa* have showed the presence of flavonoids, amino acids, phenols, glycosides, saponins and alkaloids in methanolic extract of *Boerhaavia diffusa*. The antiestrogenic activity shown by the extract may be attributed to these diverse compounds. [31]



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Cytological Activity: - The extract of *Boerhaavia diffusa* exhibited a strong depressive effect on the mitosis of *Crinum jagus* roots. Cytological Activity was conducted with the extract of *Boerhaavia diffusa* as well as the mitotic index of the control experiment was established to be 5.27. Therefore, a negative correlation between the concentrations of the test extracts and the mitotic indices found from their action. This points to an inhibition of mitosis through this *Boerhaavia diffusa* extract. Inhibition of the mitotic index increased significantly with an increase in the concentration of treatment solution of *Boerhaavia diffusa*.

Antihypertensive activity: - Vandana. S. Nade *et al.* (2015) the objective of the present study was to investigate antihypertensive potential of *Boerhaavia diffusa* roots in adrenaline-induced hypertension in rats. Blood pressure was measured weekly using non invasive tail cuff method. Blood pressure was determined by invasive method at the end of the study and also vascular reactivity was tested with adrenaline, noradrenaline and phenylephrine. The results suggested that the Methanolic extract of *Boerhaavia diffusa* possesses significant antihypertensive activity.

Analgesic and Anti-Inflammatory Activity: - *Boerhaavia diffusa* is used in 'Martinican folk medicine' for its analgesic and anti-inflammatory properties. Santhoshkumar muthu *et al.* (2014) evaluated Anti-Inflammatory Effect of Ethanolic Extract of *Boerhaavia diffusa* leaves in Wistar rats. They investigated of ethanolic extract of *Boerhaavia diffusa* reveal that the plant has wide range of phytochemical constituents and possesses free radical scavenging effect. *Boerhaavia diffusa* leaves also exhibit *in-vitro* and *in-vivo* anti-inflammatory potentials providing a scientific basis for anti-inflammatory effect in inflammatory diseases and support traditional claims. Gharate *et al.* (2013) reported anti-inflammatory, analgesic, antipyretic and antiulcer activity of Punarnavasava: an Ayurvedic formulation of *Boerhaavia diffusa*. Mudgal studied the anti-inflammatory effect of aqueous insoluble alcoholic extract of *Boerhaavia diffusa* in rats. The leaves and flower extracts have shown anti-inflammatory activity by only 55.78% decrease in rat paw edema. ^[37-38]

Anti-obesity activity: - Charan Singh *et al.* (2015) studied the estimation of anti obesity activity of ethanolic root extract of *Boerhaavia diffusa*. The focus of anti-obesity management has moved toward the herbal drugs. The On the basis of investigational data obtained, it was studied that the root extract showed significant anti-obesity action. The study indicated with the aim of the ethanolic extract from the whole plant of *Boerhaavia diffusa* revealed significant anti-obesity action.

Antioxidant activity: Satheesh and Pari demonstrated that administration of *Boerhaavia diffusa* leaf extract for 4 weeks resulted in a hydro - alcoholic extract exhibits significant antioxidant activity. Manu *et al.* (2007) investigated about the increased effect of Punarnavine on the cell-mediated immune (CMI) response compare to metastatic progression of B16F-10 melanoma cells in mice. Mili *et al.* (2007) evaluated the antioxidant activity and genoprotective effects. Venkatesh *et al.* (2013) performed screening of hepatoprotective and antioxidant activity of alcoholic and aqueous extracts of *Boerhaavia diffusa* and *Anisochilus carnosus*. Thioacetamide



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induced hepatotoxicity in rats was used to screen hepatoprotective activity. These extracts of *Boerhaavia diffusa* shows hepatoprotective and antioxidant activity in a dose dependent manner. ^[23]

Clinical trials: -

Supporting the preclinical studies several clinical studies were carried out in *Boerhaavia diffusa* extracts. These are as follows

➤ **In treatment of pulmonary tuberculosis:**

Pulmonary Tuberculosis is a widespread and frequently deadly infectious disease. Its treatment is difficult and requires long courses of multiple antibiotics. So it's necessary to found alternative methods to curb this problem. Surya *et al.* proved the extract of *Boerhaavia diffusa* used in the treatment of 25 patients of pulmonary tuberculosis as well as chemotherapy. Results showed that the no. of patients who received Punarnava along with chemotherapy be evidence for significantly faster and earlier clinical recovery. ^[39]

➤ **Anthelmintic activity:**

Singh and Udupa evaluated that dried root powders of *Boerhaavia diffusa* showed therapeutic effectiveness against soil - transmitted helminth infections. They found children or adults suffering from helminth infection became worm-free within five days when administered orally with the powder. ^[40]

CONCLUSION

Boerhaavia diffusa linn is a well-known medicinal plant that is frequently prescribed in various indigenous systems of medicine such as Ayurveda and Unani. Throughout the millennia *Boerhaavia diffusa* plant has developed into a phenomenon medicinal plant having an excess of chemical constituents helpful against a many number of disorders. This plant finds extensive importance in the traditional herb based preparations in the worldwide. *Boerhaavia diffusa* plant gets utilize as a cure for 22 disorders in Ayurvedic and Unani. *Boerhaavia diffusa* plant also finds 23 utilizes for the treatment of several clinical conditions in Brazil pharmacopeia. The plant has a number of traditional uses for ameliorating multiple diseases, which were further supported by several pharmacological and clinical studies detailing the specific bioactivity of extracts of the plant. Although there are gaps in the studies carried out so far, which need to be associated in order to develop the full medicinal potential of *Boerhaavia diffusa*, it is still very comprehensible that this is a plant with incredible extensive use nowadays and also with extraordinary potential for the future research. This review is the collection of the studies conducted on various aspects on *Boerhaavia diffusa* by different authors and the traditional healers to provide useful information for future scope of research and for conservation of this valuable species.



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