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Biological utilities of *Parthenium hysterophorus*

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Abstract: *Parthenium hysterophorus* L. (Asteraceae) is a serious weed of pastures, wasteland and agricultural fields in world. Various problems are posed by the weed to human health, agriculture, live stock production and biodiversity. It is used as folk remedy against various afflictions. The review discusses several prominent biological utilities of *P. hysterophorus* as it contains several important chemical constituents mainly histamine, saponin, glucosides and triterpene (sesquiterpene) and can be of use for the purpose of biocontrol of various pathogens , for its medicinal utility and even for the purpose of food .

Keywrods: Biocontrol, Biological utility, Folk remedy, *Parthenium hysterophorus*

INTRODUCTION

Plant *Parthenium hysterophorus* L. (Asteraceae) is labeled as serious weed of pasture, wastelands and agricultural field in world. The weed is noxious on two counts. Firstly, it is a highly adaptable weed and can grow anywhere, invade all types of pasture lands and cause substantive losses in the yield of agriculture (Aneja *et al.*, 1991; Auld *et al.*, 1983; Haseler, 1976; Jayachandra, 1971; Krishnamurthy *et al.*, 1975) secondly it is a health hazard (Dhawan and Dhawan, 1999). Direct contact with plant or plant parts, living or dead, results in dermatitis in mankind and the presence of pollens in the air cause diseases like air borne contact dermatitis (Agarwal and D'Souja, 2009), fever and asthma (Lonkar *et al.*, 1974; Rodriguez, 1975; Rodriguez *et al.*, 1976a; Shen *et al.*, 1976; Subba Rao *et al.*, 1976, 1978). Live stock is also allergic and susceptible to *P. hysterophorus*. Close contact of animal with *P. hysterophorus* may cause rashes on their whole body and udders. The active ingredient of *Parthenium* is parthenin (Rodriguez, 1975). It is responsible for bitter milk disease in live stocks fed on grass mixed with *P. hysterophorus* (Narasimhan *et al.*, 1984). Buffalo bull calves and cross bred bull calves fed on *Parthenium* mixed with conventional green fodder develop toxic symptoms leading to death with in 8-20 days (Narasimhan *et al.*, 1977). Beside this *Parthenium* has shown several prominent biological activities in animal and human models. It contains several important chemical constituents mainly histamine, saponin, glucosides and triterpene (sesquiterpene) that give this plant an importance as folk medicinal plant. Much before the menacing proportions of *Parthenium* appeared in India, the plant was known to have medicinal utility in Mexico in 1897. It was used as a folk remedy against various affliction such as ulcerated sores, certain skin diseases facial neuralgia, fever and anemia. A report of 1921 indicates that the flowers of this plant were being used as tonic, blood purifier, abortive, vermifuge, ammenagague and as an insecticide in various parts of Europe (Hansen del Orbe, 1977). *P. hysterophorus* is widely known as white top, white head, congress grass or carrot grass.

The genus *Parthenium* has about twenty species belonging to western hemisphere. It is included in family Asteraceae. *P. hysterophorus* L. is supposed to have originated as a result of natural hybridization between *P. conifertum* and *P. biplnatifidum* (Nath, 1988). The diploid chromosome number for the Indian species has been reported to be 18 (Hakoo, 1963). Two types of population of *P. hysterophorus* L. makes a complex. The plants show two distinct phases in life, juvenile, rosette or the vegetative stage and adult, mature or the reproductive stage.

The juvenile stage is rosette with dark green, pinnetisect, radical, large sized leaves and a much reduced stem. Large lower leaves are spread on the ground forming mats and they do not allow growth of any vegetation under it. Flowers are absent in juvenile stage. The adult stage is erect and much branched, up to one meter or more in height. Stems are whitish, hairy, octangular and longitudinally grooved. Leaves are simple, alternate, pinnately or bipinnately dissected, 20-30×12-25 cm, becoming smaller towards the apex of the branches. The stem and leaf surface is covered with four types of glandular and non glandular, multicellular white trichomes (Rodriguez *et al.*, 1976 b).

The inflorescence, in terminal as well as axillary populations, is peduncle, 0.5-1.5cm, corymb like, ending

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in scorpoid cyme bearing heterogamous capitula. Each capitulam is pentangular, 4-6mm across, creamy white, having five fertile florets. About 40 fertile disc florets are also present. The ray florets are pistillate, zygomorphic, epigynous, 2.0-3.5 mm in length, corolla lobes indistinct, stigma bifid, solitary basal anatropus ovule; bract ovate and transparent showing prominent venation. The fertile disc florets are staminnated, actinomorphic, epigynous; corolla five lobed, infundibulform; bract oblanccolate, boat shaped, 2-3 mm in length; stamen five and syngenesious. The sterile disc florets are neutral. The cypsela is obovate to ellipsoid, light brown when young and drak brown when mature, crowned by persistant corolla appendages and style, 2-3 mm × 1-2 mm., pappus are absent (Haseler, 1976; Singh and Chandra, 1982). The dried ray florets having mature seeds are shed along with two sterile disc florets and subtending bract as a unit called achene complex.

The time interval between anthesis and seed shedding is only 13-15 days. Average sized plant produces as many as 25,000 seeds (Haseler, 1976). The plant exclusively reproduces by sexual method but possess a remarkable power of regeneration. Pollination and dissemination of seed both are anemorphillous. Depending upon the frequency and distribution of rains during the year, the plant can complete one, two or even three generations (Singh *et al*., 1993).

The seed of *Parthenium* do not germinate immediately after ripening as the achenes first need to disperse and release several inhibitors of germination (Picman and Picman, 1984; Kohli *et al*., 1985). The germination of *P. hysterophorus* reaches a maximum 1-6 months after the achenes ripen. The seeds are not able to germinate in soil below a depth of 5 cm. *P. hysterophorus* flowers are grown about 30-45 days after germination. The whole plant cycle is completed within about 5 months. A single plant produces an average of 810 flower heads (Labrada, 1988). A photoperiod of 13 hours and warm conditions are conductive in flowering (Williams and Groves, 1980).

ORIGIN AND SPREAD

P. hysterophorus Linn. (Asteraceae) considered a serious weed in several tropical and subtropical countries across the world (The wealth of India, 2003) is supposed to have originated in North East Maxico (Dale, 1981; Haseler, 1976; McClay, 1984) and during the last hundred years has found its way to Africa, Australia and Asia. It has been reported from United States, Central America, South America, West Indies, Lesser Antilles of the new world and from India, Nepal, Africa, China, Vietnam and Australia of the old world (Towers *et al*., 1977; Aneja *et al*., 1991). It is a weed of roadsides, vacant lots and non cropped areas along non disturbed habitat (Singh *et al*., 1993) and has also been recorded as a minor pest of cultivation in United States, Brazil, Argentina (Muenscher, 1955) and India (Krishnamurthy *et al*., 1993; Saraswat, 1993; Dhawan and Dhawan, 1994). The weed was first brought to India as an ornamental plant in 1910 but it failed to catch up. Again it invaded India and Australia in fifties as contamination of wheat and pasture seeds, imported for the United State of America (Rao, 1956; Haseler, 1976). In India it was first reported as a weed from North India in 1979 (Sharma and Tyagi, 1979).

As a species facing little environmental resistance *Parthenium* has become a menace in wastelands and non cropped areas (Singh *et al*., 1993). Nitrogenous wastes of humans and livestock promotes its growth (). This is the reason of the extensive growth of the weed close to cities and other human settlements. Under suitable soil and moisture conditions it becomes dominant species and results in the exclusion of beneficial plants (Jayachandra, 1971; Kanchan, 1975; Krishnamurthy, *et al*., 1975; Dale, 1981). Till 1977 the weed did not find any place in the world's worst seeds (Holm, *et al*., 1977). Now a day, it has become one of the seven most dangerous weeds of the word.

PHYTOCHEMISTRY OF *P. HYSTEROPHORUS*

Whole plant: Two types of sesquiterpene lactones, hysterin and dihydroisoparthenin have been isolated from plant *P. hysterophorus* (Picman *et al*., 1982). Histamine (0.585%) is present in aerial parts of the plant (Kamal and Mathur, 1991). Syringaresinal has also been isolated from this weed (Das *et al*., 1999).

Three ambrosanolides; α-epoxymethylacrylyloxy parthenin, its 11α13-dihydro derivatives and 8α-eposeymethylacrylylos-ambrosin; have been isolated from chloroform extract of the aerial parts of the *P. hysterophorus* (Chhabra *et al*., 1999). A normal sesquiterpenoid, charminarone (the first seco-pseudo-guaianolide) has been isolated from the whole plant (Venkataiah *et al*., 2003).

Relative compositions of these lactones vary in different species of *Parthenium*. Parthenin is characteristic of *P. hysterophorus* while hysterin, hymenin and ambrosin of *P. kipinnatifidum*. Hysterin is the major sesquiterpene of *P. glomeratum*. Quercetagetin 3,7-dimethyl ether is a major flavanol present in this plant (Shen *et al*., 1976).

Small amount of 6-hydroxylaemferol, 3,7-dimethyl ether and the glucosides, quercetin3-0-glucoside, Kaemferol 3-0-glucoside and kaempferol 3-0-arabino glucoside have also been isolated from *P. hysterophorus* (Rodriguez, 1975). Phenolic glucosides show fluctuations in number and amount depending on the collection of site. Accumulation of fumeric acid in stem and leaves and ferulic acids in all parts of the plant except pollens, have also been reported. These phenolic acids are said to be responsible for allelopathic impact of plant *P.*

hysterophorus on other plants (Kanchan, 1975).

Leaves: Parthenin, hexacosanol, myricyl alcohol, β–sitisterol, campesterol, stigmasterol, betulin, ursolic acid, β-D-glucoside of β-sitosterol and saponin have been isolated from leaves of *P. hysterophorus*. The saponin on hydrolysis yield oleanolic acid and glucose.

The aqueous extract of *P. hysterophorus* contains free amino acids, glucose, galactose and potassium choloride (4.8%) (Gupta *et al*., 1977). Methoxypseudoguaianolides viz. 13-ethoxy-dihydroambrosin, 13-methoxydihydro-parthenin and 2β,13α-dimethoxy- dihydroparthenin have been isolated from leaves of this plant (Bhullar *et al*., 1997). The leaves also contain parthenin, caffeic, chlorogenic, p-hydroxybenzoic, vanilic, salicylic, gentisic, neo-chlorogenic and proto-catechuic acids (The wealth of India, 2003). The allelochemical parthenin is sequestered at high level in capitate-sessile tirchomes on leaf surfaces of *P. hysterophorous* (Rainhardt *et al*., 2005). Leaves contain about 5% parthenin (The wealth of India, 2003).

Flower: Methanolic extract of flower of *P. hysterophorous* contains several constituents such as 2β-hydroxycoronopilin, 8β-hydroxycoronopilin, 11-H,13-hydroxyparthenin, parthenin and coronopilin. Parthenin up to 8% is present in capitulum (The wealth of India, 2003). A new highly oxygenated pseudoguaianolides (8-β-acetoxyhysterone C), parthenin, coronopilin and hysterone C have also been isolated from the flowers (Ramesh *et al*., 2003; Das *et al*., 2005,2007).

Root: Histamine (0.35%) is present in the roots of plant *P. hysterophorus* (Kamal and Mathur, 1991). The roots contain parthenin, caffeic, chlorogenic, p-hydroxybenzoic, p-anisic, vanilic, salicylic, gentisic, neo-chlorogenic and proto-catechuic acids (The wealth of India, 2003).

Biological activities: Sesquiterpene lactones exhibit a wide spectrum of biological activities, which include cytotoxic, antitumour, allergen, antimicrobial, antifeedant, phytotoxic and insecticidal properties (Rodriguez *et al*., 1976a). The sesquiterpene lactone parthenin is the main secondary metabolite of *P. hystorophorus* L. (Compositae) and possess all the properties mentioned above. Parthenin the major sesquiterpene lactone becomes useful when properly processed. The early reports suggest that parthenin can be used in pest and pathogen control, either by it self or as a lead compound for the development of active and more selective analogues (de la Fuente *et al*., 2000; Datta and Saxena, 2001; Fazal *et al*., 2011).

Insecticidal: Parthenin the active compound present in *Parthenium hysterophorus* is known to show activity against termites, cockroaches (Tilak, 1977) as well as migratory grasshoppers, *Melanoplus sanguinipes* [F] (Picman *et al*., 1981; Fagoonee, 1983). Whole plant extract of *Parthenium hysterophorus* showed insect growth regulatory activity against the cotton stainer, *Dysdercus angulatus* [F] (Kareem, 1984), fifth instar larvae of *S. litura* (Ranjandran and Gopalan, 1979; Balasubramanian, 1982) and toxic effect on cabbage leaf webber (*Crocidolomia binolalis* Zell), and pulse beetle (*Callosobruchus maculates* F) infesting cowpea seeds (Bhaduri *et al*., 1985) and mites (Gupta, 1968). The natural occurring resin material of the guayul plant (*Parthenium* spp.) has been demonstrated to protect wood against termite, molluscan borer and fungal attacks (Bultman *et al*., 1998). Petroleum ether extract of leaves, stem and inflorescence of *P. hysterophorus* shows toxic effect on mean life span and progeny production of adults of the mustard aphid, *Lipaphis erysimi* (Sohal *et al*., 2002). The environmental biologists have identified its cholinesterase antagonistic properties which can be used in control of insects and worms (Dhawan and Dhawan, 1995).

Antifeedant: *Parthenium* has been shown to act as a feeding deterrent to the adult of *Dysdercus koenigii* F., *Tribolium castaneum* Hbst, *Phthorimaea operculella* (Zell), *Callosobruchus chinensis* L. (Sharma and Joshi, 1977) and sixth instar larvae of *Spodoptera litura* (F) (Datta and Saxena, 1997).

Nematicidal: Extract of *P. hysterophorus* show toxicity against root knot nematodes *Meloidogyne incognita* (Kofoid and white), Chitwood, *Helicotylendus dihyslera* (Cobb) sher (Hasan and Jain, 1984). Crushed leaves admixed into the soil are used to reduced root galling in papaya caused by *M. incognita* (de la Fuente *et al*., 2000).

Herbicidal: Pure parthenin as well as extract of different parts of *P. hysterophorus* show phytotoxic effects on many aquatic (Pandey, 1994,1995,1996) as well as terrestrial weeds (Khosla *et al*., 1980; Khosla and Sobti, 1981; Kumari, 1990; Singh *et al*., 1992; Batish *et al*., 1997; Acharya and Rahman, 1997). The sesquiterpene lactone parthenin has received most attention regarding allelopathy or potential herbicidal properties of the plant (Duke *et al*., 2007).

Antifungal: Antifungal potential of different extracts of *P. hysterophorus* against human pathogenic fungi were investigated by Rai and Upadhyay (1990) and Rai (1993, 1994, 1995). The dermatophytes and other fungal pathogens have been found to be sensitive to sesquiterpene lactones which are present as active agent in Asteraceous plant *P. hysterophorus* (Rai *et al*., 2003).

Antiamoebic: Antiamoebic activity of parthenin from *P. hysterophorus* has been evaluated *in vitro* against axenic and polyxenic cultures of *Entamoeba histolytica*. Parthenin has been found to show acute toxicity to the cultured organisms. Parthenin has activity comparable to that of metronidazol (Sharma and Bhutani, 1988).

Antimalarial: Parthenin and some of its derivatives were

evaluated for antimalarial activity against a multi drug resistant strain of *Plasmodium falciparum*. Parthenin and related compounds have significant antimalarial action (The wealth of India, 2003).

Trypanocidal: Crude ethanolic extract of plant *P. hysterophorus* shows activities against *Trypanosoma evansi*. The extract exerts antitrypanosomal effect at intraperitoneal doses of 100 and 300 mg/kg body weight when used for treatment of infected rats (Talakal *et al.*, 1995).

Antibactarial: The volatile oil which contains sesquiterpene and flavanoids were found to be highly effective against gram positive and gram negative bacteria (Chopra, 1960) and various species of dermatophytes (Dikshit and Dixit, 1982).

Antiviral: *Parthenium* extract exhibits significant antiviral action against potato virus Y. This virus extensively damages the chilli crops. Parthenin might find use as an effective agent against potato virus Y (The wealth of India, 2003).

Cytotoxic: Pseudoguaianolides and their analogues exhibit cytotoxic effect (Das *et al.*, 2007). Themethanolic extract of *P. hysterophorus* has been found to have antitumour effect in host mice bearing transplantable lymphocytic leukemia. The active compound leads to slow development of tumour and increases the survival of mice bearing lymphocytic leukemia (Mukherjee and Chatterjee, 1993). Studies conducted at the Cancer Research Institute, Bombay and in vitro ctotoxicity against human cancer cells have shown that *P. hysterophorus* possess anticancerous properties (Haq *et al.*, 2011, Ramamurthy *et al.*, 2011).

Parthenin exhibits cytotoxicity with chromosomal aberrations in peripheral blood lymphocytes when administered to mice. A single intra-peritoneal dose of 4-31 mg/kg body weight of animal of parthenin increases the frequency of micronucleated reticulocytes in mice (Ramos *et al.*, 2002).

Pharmacology: Oral administration of ethanolic extract of this plant leads to various behavioural as well as physiological changes like decrease in body weight erythrocyte count, haemoglobin and lymphocyte percentage and increase in relative liver weight, neutrophill and leukocyte count in rat (Kushwaha and Maurya, 2010, Maurya and Kushwaha, 2010). The leaf extract of plant *P. hysterophorus* shows depolarizing neuromuscular junctional blocking action in rats similar to that of neostigmine (Vijayalakshmi *et al.*, 1999). *P. hysterophorus* induce changes in neurotransmitter levels in mouse brain which in turn affects the physiology of the peripheral endocrine glands in mice (Verma *et al.*, 2006). 10% cold aqueous extracts of flowers successfully elicit a hypotensive response in dogs (The wealth of India, 2003).Methnolic extract of the plant is reported to cause significant relaxant activity on skeletal muscles and depressant on central nervous system (Jha *et al.*, 2011 a, b).

P. hysterophorus L. whole plant is used as allergen (Dwivedi *et al.*, 2008). It also shows hypoglycemic effect in normal and diabetic rats (Patel *et al.*, 2008). The flower extract has apasmogenic action in isolated rabbit duodenum (The wealth of India, 2003).

The flower extract possess cardiac depressant effect as concluded from experiments on perfused frog heart. Aqueous extract of flowers and leaves exert lethal effect on frog tadpoles. Phytoconstituents particularly phytotoxins present in extracts have been reported to be responsible for this action (The wealth of India, 2003). The plant is also reported to be effective in neuralgia, dysentery and as stimulant to menstrual functions (Dhawan and Dhawan, 1995).

AS FOOD

As food, the leaf protein from this plant is reported to be better than cereal and legume proteins. It is used as spices in many parts of the world . The leaf protein concentrate contains; protein 48-54%, ether extract 11-13%, ash 6-8% etc. (Khan *et al.*, 2011). Parthenin free dried fibres of the plant contain 1.6-2.4% of N_2 and can be used as cattle feed (Narasimhan *et al.*, 1993).

Conclusion

The presence of several important chemical constituents mainly histamine, saponin, glucosides and triterpene (sesquiterpene) in the weed plant *P. hysterophorus* and their prominent biological activities in animal and human-models indicate that the weed can be of use as insecticidal, antifeedant, nematicidal, herbicidal antifungal, antiamoebic, antimalarial, trypanocidal, antibacterial, antiviral. Active compounds and their analogues due to cytotoxic and pharmacological activities in future may find an important place as medicine. The nutrional value of the plant indicates its utility as food and fodder also.

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