Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 14	No. 3	pp. 463-474	2015

Review Research Paper

Parthenium hysterophorus L.: Harmful and Beneficial Aspects - A Review

Rachna Bhateria, Renu and Snehlata†
Department of Environmental Sciences, Maharshi Dayanand University, Rohtak-124 001, Haryana, India
†Corresponding author: Snehlata

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 29-9-2014
Accepted: 23-11-2014

Key Words:
Parthenium hysterophorus
Invasive plant species
Weed
Asteraceae

ABSTRACT

Invasive plant species have the potential to damage crops, industries, environment and public health, hence scientists, academicians, leaders of industry and land managers are realizing that invasive species are serious environmental threats for the 21st century. *Parthenium* weed is an annual herb in the family Asteraceae which is native to northern Mexico and southern USA. It is spreading across the length and breadth of our country. It gets easily established in almost all the places such as wasteland, roadsides, forests, railway tracks, crop fields, etc. Its high germination ability throughout the year, an enormous seed bank, rapid spread, colonization and extreme adaptability in a wide range of habitats is responsible for its wide spread occurrence. *Parthenium hysterophorus* L. was reported to be one of the seven most dangerous weeds of the world. It has achieved a major weed status in India and Australia within a relatively short period due to its fast multiplication, rapid growth and its ability to compete with other native flora. There are many ways like mechanical, chemical, cultural and biological to control it, but it cannot be controlled by using a single approach. Integrated approach should be the better way to manage this noxious weed. The aim of this review is to provide general information about the physiology, distribution, ill effects and management of *Parthenium* .

INTRODUCTION

Parthenium hysterophorus L. is commonly called as congress grass, carrot weed, white top etc. Some of the vernacular names by which *Parthenium* is known are chatak chandani, broom brush, gajari and safed topi. It is among the top ten worst weeds of the world and has been listed in the global invasive species database (Aneja 1991, 1998). It occurs widely and has occupied almost all the parts of the world such as Asia (Bangladesh, India, Israel, Pakistan, Nepal, southern China, Sri Lanka, Taiwan, Vietnam), Africa (Ethiopia, Kenya, Madagascar, Mozambique, South Africa, Somalia, Swaziland and Zimbabwe), Australia and the Pacific (New Caledonia, Papua New Guinea, Seychelles, Vanuatu). In India it has invaded almost all the states with highest occurrence in Haryana, Punjab and U.P. It was first reported in India in 1880, but recognized as a threat in 1950s. In 2005, it was estimated that it infested over five million acres of the Indian subcontinent (Kohli et al. 2006). Due to its high fecundity, a single plant can produce 10,000 to 15,000 viable seeds and these seeds can disperse and germinate to cover large areas. As *Parthenium* does not reproduce vegetatively from plant parts, hence seeds dispersal is the only method of reproduction. In summer, plants can flower and set seed four weeks after germination because they are stressed and small. Buried seeds have been found to last much longer than seeds on the soil surface. Timing of chemical control is critical. *Parthenium* weed should be removed when plants are small and have not produced seeds. According to Holm et al. (1997), this noxious invasive species is considered to be one of the worst weeds currently known. This is a weed of global significance responsible for agricultural losses, severe human and animal health issues, such as, dermatitis, asthma and bronchitis besides a great problem for biodiversity. The weed has also been identified in Jessore, Faridpur, Norail, Magura, Rajshahi, Natore, Sirajgonj, Manikgonj, Dhaka and Mymensingh districts of Bangladesh (Karim & Forzwa 2010). Nowadays *Parthenium* weed is being dispersed through vehicles and agricultural commodities. Toxic and inhibitory constituents present in various parts (stem, leaves, leaf hair, flower, pollen grain) of *P. hysterophorus* are summarized in Table 1 (Roy & Shaik 2013).

BOTANICAL DESCRIPTION

The genus name *Parthenium* is derived from the latin word parthenice, a reference to the plant now known as *Tanacetum Parthenium* (L.) Bernh. or 'feverfew'; *hysterophorus* was derived from the Greek *hystera* (womb) and *phoros* (bearing), referring to the prolific seeding habit of the plant (Parsons & Cuthbertson 1992). It is commonly called as bitter weed, carrot weed, broom bush, congress grass (India); whitetop, escobar amarga and feverfew (Caribbean); false ragweed and ragweed *Parthenium* (USA).

Classification: *P. hysterophorus* L. of the family Asteraceae (Tribe: Heliantheae), is fast maturing, erect and much

branched annual or ephemeral herb. It shows two distinct phases in life; juvenile, rosette or the vegetative stage and adult, mature or the reproductive stage. The juvenile stage exhibits a rosette with large, dark green, simple, radicle, pinnetisect small leaves lacking flowering (Fig. 1 A). The adult stage is erect, much branched with deep tap root system that reaches up to 2 m in height (Fig. 1 B) (Lakshmi & Srinivas 2007).

Habit: Plant *Parthenium hysterophorus* is an annual weed plant with a deep taproot and an erect main stem. The weed usually grows to a height of 1-1.5 m, sometimes it can grow as high as 2 m (APFISN). *Parthenium* grows luxuriantly in wastelands, public lawns, orchards, forestlands, flood plains, agricultural areas, urban areas, overgrazed pastures, industrial areas, playgrounds, roadsides, railway tracks and residential plots.

Stem, leaves and flowers: Its main stem is green when young but becomes woody at maturity, highly branched bearing flowers at the top of each branch. The branching gets highly increased at the time of flowering to bear more flowers and produce large number of seeds. Its leaves are deeply-lobed, pale green and covered with soft and fine hair up to 30 cm in length, close to the soil, alternate, sessile, irregularly dissected having small hair on both the sides. The number of leaves per plant ranges from 6 to 55 (APFISN). Flowering occurs after one month of germination. The fruit is called cypsela, each flower contains five seeds which are wedge shaped, black, 2mm long with thin white scales. A single plant can produce up to 100000 seeds in its life cycle. Seeds do not have dormancy period and are capable of germinating any time when moisture is available. The highest germination rates are at temperature from 12-27°C (Iqbal et al. 2014).

Dispersal and germination of seeds: The seeds are mainly dispersed through water currents, livestock and other animals and by movement of vehicles, machinery, grain, stock feed etc. and to a lesser extent by the wind. Most of the long distance spread is through vehicles, farm machinery and flooding. The spread of seeds plus their ability to remain viable in the soil for many years pose one of the most complex problems for control (Monaco et al. 2001). Seeds germinate within a week with the onset of monsoon and flowering starts after a month and continues up to another three months. In north-west India, *Parthenium* germinates mainly in the months of February-March, attaining peak growth after rains in June-July and produces seeds in September-October. It normally completes its life cycle within 180-240 days. Its growth remains less and stunted from November to January due to severe cold (Aneja 1991, 1998). Complete plant of *Parthenium* is shown in Fig. 2. *Parthenium hysterophorus* has multiple harmful aspects and no particular use. Several physical and chemical methods have been used in the past to eliminate this weed, but they proved ineffective, expensive and not eco-friendly. The biomass of this plant is not put to any use and disposed along the roadsides, agricultural fields and railway tracks after uprooting. Further, this weed is burnt in order to prevent various ailments induced by its toxic sesquiterpene lactone. The *Parthenium* seed has the ability to undergo dormancy. The seed banks are persistent, with seed viability greater than 50% after more than two years in the soil. Seed near the soil surface is rarely viable beyond 2 years. Undisturbed buried seed will stay dormant for a longer period. It has been recorded as viable for up to 6 years and anecdotal evidence suggests even longer period (Gnanavel 2013).

CAUSES OF RAPID SPREAD OF *PARTHENIUM*

High reproductive potential: *Parthenium* weed is an extremely prolific seed producer, with up to 25,000 seeds per plant (Navie et al. 1996) and with an enormous seed bank, estimated at 2,00,000 seeds/m^2 in abandoned fields (Joshi 1991). Seeds of *Parthenium* can germinate any time of the year, given suitable moisture levels, remain viable for a long time and can thrive under very harsh environmental conditions (Williams & Groves 1980).

Fast growth rate: It is a very fast maturing annual. Generally, plants commence flowering when they are 4 to 8 weeks old and may flower for several months. Under unfavourable conditions such as under drought stress, the weed can germinate, grow, mature and set seeds in four weeks.

Allelopathic potential: *Parthenium* inhibits the germination and growth of other plants by allelopathy. Srivastava et al. (1985) discovered that aqueous extracts of leaves and inflorescence inhibited the germination and growth of barely, wheat and peas. Kumari et al. (1985) showed that cell survival and chlorophyll content were markedly reduced when *Parthenium* extracts were directly sprayed on the crop plants.

Unpalatable to animals: Literature shows that buffalos, cows and sheep do not eat *Parthenium* while goats can (Javaid & Anjum 2005). Earlier investigations in India had revealed serious health hazards to the livestock in *Parthenium* invaded areas. In artificial feeding tests buffalo, bull, calves accepted the weed, alone or in mixture with green fodder, with severe consequences. Majority of these developed severe dermatitis and toxic symptoms and died within 8-30 days (Narasimhan et al. 1977).

HEALTH BENEFITS OF *PARTHENIUM*

Parthenium hysterophorus has been found to be

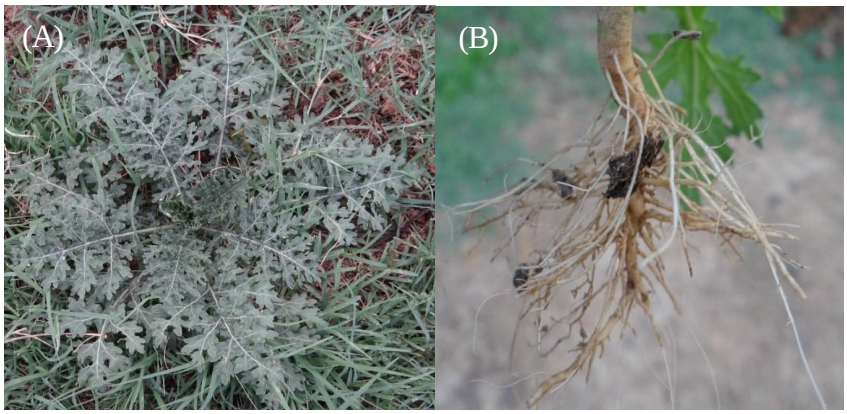

Fig. 1: Parthenium weed: (A) Rosette stage of Parthenium plant; (B) Tap root system of Parthenium (Kaur et al. 2014).

Fig. 2: Parthenium plants at flowering stage (Photo Credit: Australian Weeds Committee 2012).

pharmacologically active as analgesic in muscular rheumatism, therapeutic for neuralgia and as vermifuge (Maishi et al. 1998). This weed is also reported as promising remedy against hepatic amoebiasis. Parthenin, the major constituent of the plant, exhibits significant medicinal attributes including anti-cancer properties (Venkataiah et al. 2003). Ramos et al. (2002) had established the anti-tumour potential of *P. hysterophorus* extracts *in vitro* and *in vivo* with positive results in terms of tumour size reduction and overall survival of cell lines. Aqueous extract of *P. hysterophorus* has hypoglycaemic activity against alloxan-induced diabetic rats (Patel et al. 2008). The methanol extract of the flowers showed significant antitumour activity and parthenin exhibited cytotoxic properties against T cell leukaemia, HL-60 and Hela cancer cell lines (Das et al. 2007). Hence, flower extract of this weed can be used for developing drug for diabetes mellitus. *Parthenium hysterophorus* has been found to be pharmacologically active as analgesic in muscular rheumatism, therapeutic for neuralgia and as vermifuge (Maishi et al. 1998). This weed is also reported as promising

remedy against hepatic amoebiasis.

CONTROL OF *PARTHENIUM* WEED

Various methods, e.g. physical, chemical, bioherbicidal and integrated, which are being practiced to manage this weed around the globe as discussed below:

Physical control: Manual uprooting of *Parthenium* before flowering and seed setting is the most effective method. Uprooting the weed after seed setting will increase the area of infestation. Some landholders have achieved success in ploughing the *Parthenium* weed in the rosette stage before it seeds, but this must be followed up by sowing a crop or direct seeding the perennial pasture. Physical control involves hand weeding, a time consuming and unpleasant job, made worse by the health hazards involved with handling *Parthenium* weed. If uprooting is done after the flowering stage, the pulled out plants are to be burnt without transporting too far off places, to avoid seed dispersal. Manual method also finds a place in the integrated approach in order to achieve quick results. But manual method is neither economical nor practicable in vast areas with heavy infestation. In limited situations the method can work, that too by engaging persons insensitive to *Parthenium* allergy for uprooting the plants. Even in such cases, safety measures such as wearing of hand gloves and nose covers are necessary, but this method alone is only temporary and needs to be repeated (Mahadevppa 1993).

Chemical control: Chemical control is an effective method to control *Parthenium* in the areas where its natural enemies are absent. Use of chemical herbicides, such as chlorimuron ethyl, glyphosate, atrazine, ametryn, bromoxynil and metasulfuron, are known to be very effective in controlling this weed. The application of 2,4-D EE (0.2%) and metribuzin (0.25 and 0.50%) was found more effective in controlling *Parthenium* at 15 days after spraying (DAS), which caused complete kill of *Parthenium* population and didn't allow any emergence of weed (Javaid 2007, Mishra & Bhan 1994, Gaikwad et al. 2008). In open wasteland, non cropped areas, along railway tracks and roadsides, spraying the solution of common salt (sodium chloride) at 15-20% concentration has been found to be effective. The use of synthetic herbicides such as alachlor, paraquat, simazine, 2,4-D, 2,4,5-T, glyphosate, atrazine and metribuzin is effective (Shabbir 2012). The timing of chemical control is critical, which is sprayed before flowering in open waste lands, non cropped areas, railway tracks and road sides. The spray having a concentration of sodium chloride @ 20% concentration has been found most effective (Sankaran 2011).

Allelopathic control: The term allelopathy was coined by Molisch (1937), which generally refers to the detrimental effect of one plant species on seed germination, growth and reproduction of another plant species. Numerous plants have been reported to possess allelopathic potential and efforts have been made to use them in weed control (Knox 2008). A study in India revealed that *Cassia sericea* reduces the accumulation of *Parthenium* by 70% and *Parthenium* population by 52.5% (Kandasamy & Sankaran 1997). Another study showed that aqueous extracts from *Imperata cylindrical*, *Desmastachya bipinnata*, *Otcantium annulatum* and *Sorghum halepense* markedly suppressed seedling growth and germination of *Parthenium* (Javaid et al. 2005). Both the root and shoot extracts of three allelopathic grasses *viz*., *Dicanthium annulatum*, *Cenchrus pennisetiformis* and *Sorghum halepense*, reduced germination and suppressed early seedling growth of exotic weed *P. hysterophorus.* Aqueous foliar extracts of *Azadirachta indica*, *Aegle marmelos* and *Eucalyptus tereticomis* totally inhibited the seed germination of *Parthenium* and may be exploited for controlling *Parthenium* weed.

Biological control: Biological control is an environmentally sound and effective means of reducing or mitigating pests and pest effects through the use of natural enemies. In the last three to four decades, a great deal of emphasis has been given to control *Parthenium* through various biocontrol agents like microbial pathogens, insects and botanicals (Ray & Gour 2012, Watson & Wymore 1990). There are two basic strategies to implement the biological control of weeds, (1) the introduction of foreign pathogenic organisms, called the 'classical approach', and the 'augmentative' or 'bioherbicidal approach', where the pathogenic organisms are already present (native or introduced), and (2) their population is increased by mass rearing. In epidemiological terms, these approaches are described as 'inoculative' and 'inundative strategy' respectively (El-Sayed 2005). Singh (1997) reported that the most economic and practical way of managing *Parthenium* is by the use of biological control agents and exploitation of competitive plants. Biological control of *Parthenium* through insects, pathogen and competitive plants gained momentum in India in 1980s with publication of more reports about the indigenous bioagents infesting *Parthenium.*

Biological control through competitive plants: Most of the work on this approach has been carried out in India and now gaining momentum in other countries too. Yaduraju et al. (2005) reported many competitive plant species from different climatic zones of India like *Cassia tora, Croton bonapladanium, Croton sparsiflorus, Cannavis sativa, Hyptis suaveolens, Amaranthus spinosus, Sida acuta, Tephrosia purpurea, Stylosanthes scabra, Cassia auriculata, C. obtusifolia,* etc. In Madhya Pradesh, the use of marigold was also advocated to suppress the growth of

Table 1: Toxic and inhibitory constituents present in *Parthenium.*

Main groups	Constituents	References
Terpenoids	*Sesquiterpene lactones:* germacranolides (including parthenolide, artemorinand chrysanthemonin) guaianolides (including chrysartemin A, partholideand chrysanthemolide) and eudesmanolides (including santamarin, reynosinand magnolialide), parthenin, cornopolin, artecanin, balchanin, costunolide,epoxyartemorin	(Parsons & Cuthbertson 2001, Boon & Smith 2004, Pareek et al. 2011)
	α-unsaturated γ-lactones: 3-β-hydroxy- parthenolide, costunolide, 3-α-hydroxycostunolide, 8-α-hydroxyestafiatin, artecanin, two chlorine containingsesquiterpene lactones, 1-β-hydroxyarbusculin and 5-β-hydroxyreynosin	(Barnes et al. 2007)
Volatile oils (0.02–0.07%)	Various monoterpene and sesquiterpene components (e.g. camphor(56.9%), camphene (12.7%), p-cymene (5.2%), bornyl acetate (4.6%), tricylene, α-thujene, α-pinene, β-pinene, α-phellandrene, α-terpinene, γ-terpinene, chrysantheone, pinocarvone, borneol, terpinen-4-ol, ρ-cymen-8-ol, α-terpineol, myrtenal, carvacrol, eugenol, trans-myrtenol acetate, isobornyl 2-methyl butanoate, caryophyllene oxide, germacrene, farneseneand their esters)	(Barnes et al. 2007, Pareek et al. 2011)
Amino acids	Rich in Glycine and proline and moderate amount with alanine and lysine	(Gupta et al. 1996)
Amino sugars	N-acetylgalactosamine and N-acetylglucosamine	(Gupta et al.1996)
Phenolic derivatives	Caffeic, vanllic, ferfulic, chlorogenic and anisic acids	(Parsons & Cuthbertson 2001)
Flavonoids	Luteolin, apigenin, 6-hydroxykaempferol 3,6-dimethyl ether, 6-hydroxykaempferol 3,6,4'-trimethyl ether (tanetin), quercetagetin 3,6-dimethyl ether, quercetagetin 3,6, 3'-trimethyl ether (accompanied byisomeric 3,6, 4'-trimethyl ether), quercetin, chrysoeriol, santin, jaceidin andcentaureidin	(Pareek et al. 2011)
Others	8-β-Acetoxyhysterone C, Charminarone, 8α-Epoxymethylacrylyloxyambrosin, 8α-Epoxymethylacrylyloxy-11, 13-dihydroparthenin, 8α-Epoxymethylacrylyloxyparthenin, 2β-Hydroxycoronopilin, Hysterone (A, B, C, D), 1α, 2β, 4β-Trihydroxypseudoguaian-6β, 12-olide, Pyrethrin, tannins (typeunspecified), melatonin, potassium chloride, protein	(Parsons & Cuthbertson 2001, Barnes et al. 2007, Zhou et al. 2011b,c,d,e,f)

Parthenium in the protected areas (Kauraw et al. 1997). In the same state, heavily infested *Parthenium* sites were replaced at many places by deliberate broadcasting of seeds of *C. tora* during March-April (Kumar & Varshney 2008). In Delhi, Gautam et al. (2005a) identified about 23 plant species suppressing *Parthenium*. They advocated deliberate use of *Kochea indica* for replacement of *Parthenium* in the area. In Maharashtra, *Cassia tora*, *Hyptis suavelones*, *Tephrosia purpurea*, *Xanthium strumarium*, etc. were found to compete with *Parthenium* (Sarkate & Pawar 2005, Gaikwad 2006). Table 2 summarises some uses of *P. hysterophorous.*

Insects as classical biocontrol agents: Several insects have been tried to control *Parthenium* weed in different countries. Of the various insects, the leaf-feeding beetle (*Zygogramma bicolorata*) and the stem galling moth (*Epiblema strenuana*), both imported from Mexico, have shown good potential to control this weed. The beetle, *Z. bicolorata*, an effective leaf eater, was imported from Mexico for the management of *Parthenium* in Australia in 1980 and in Indian Institute of Horticulture Research (IIHR) Bangalore in 1984 (Jayanth 1997). Both the adults and larvae of this insect feed on leaves. The early stage larvae feed on the terminal and auxiliary buds and move on to the leaf blades as they grow. The fully-grown larvae enter the soil and pupate. An insect density of one adult per plant caused skeletonization of leaves within 4-8 weeks, but little success has been achieved as the weed has very high generative potential and moreover the insect is not a species specific and is found to attack sunflower in India (Dhileepan 2001).

Table 2: Possible utilization of *P. hysterophorus*.

Uses	References
Removal of heavy metals from environment to sequester Cd(II) ions from soil	Ajmal et al. (2006)
Sequestration of Ni(II) from aqueous solution onto activated carbon	Lata et al. (2008)
Eradication of salvinia and water hyacinth from water bodies	Pandey (1994)
Carbonized *Parthenium* can be used for removal of dyes, heavy metals, nitrates and phenols	Rajeshwari & Subburam(2002)
Parthenium based activated carbon has excellent cresol adsorptive characteristic	Singh et al. (2008)
Additive with cattle manure in biogas production	Gunaseelan (1987)
Ovicidal, anti-fleedant, and nematocidal activity	Datta & Saxena (2001)
P. hysterophorus can be used as low-cost substrate for xylanase production	Dwivedi et al. (2009)
As compost; green manure for maize and mungbean production	Kishor et al. (2010), Javaid (2008)
Silver nanoparticles formation for biomedical uses	Parashar et al. (2009)
Parthenin exhibits significant anticancer property	Das et al. (2007)
Folk remedy against skin diseases, ulcerated sores, facial neuralgia, fever and anaemia	Venkataiah et al. (2003)
As analgesic in muscular rheumatism and vermifuge to eliminate helminths	Maishi et al. (1998)
Treat inflammation, eczema, skin rashes, herpes, rheumatic pain, cold heart trouble and as a remedy for female ailments	Maishi et al. (1998)
Treat fever, diarrhoea, neurologic disorders, urinary infections, dysentery, malaria and as emmenagogue	Surib-Fakim et al. (1996)
Flea-repellent for ridding dogs	Maishi et al. (1998)
Animal feed due to high potash, oxalic acids and protein	Mane et al. (1986)

Management by utilization: One of the most effective methods to manage the *Parthenium* is the large scale utilization of this weed. The weed has been well documented for its insecticidal (Gajendran & Gopalan 1982), nematicidal (Bala et al. 1986) and herbicidal (Pandey et al. 1993) properties. The weed is also used for oxalic acid and biogas production (Gunaseelan 1987, Bhan et al. 1997). *Parthenium* can be managed by using it as green manure. It is able to extract nutrients even from nutrient deficient soils. Many scientists and research scholars have started using this obnoxious weed extract for their insecticidal, nematicidal and herbicidal properties (Ambasta & Kumari 2013).

As a potential source of bioherbicide: Allelopathy is considered a multidimensional phenomenon occurring constantly in natural and anthropogenic ecosystems (Gniazdowska & Bogatek 2005). It is defined as the interaction between plants and microorganisms by a variety of compounds usually referred to as allelopathins, allelochemicals, or allelopathic compounds. Allelochemicals or plant derived chemicals offers a great potential for the pesticides because they are comparatively safe for the environment. Allelochemicals are released into the environment by plant organs such as roots, rhizomes, leaves, stems, bark, flowers, fruits and seeds. These compounds belong to numerous chemical groups including: trike tones, terpenes, benzoquinones, coumarins, flavonoids, terpenoids, strigolactones, phenolic acids, tannins, lignin, fatty acids and nonprotein amino acids. In the past two decades, abundant work has been done on plant derived compounds as environmentally safe alternatives to herbicides for the weed control (An et al. 1998, Duke et al. 2002). Several researchers (Tefera 2002, Stephen & Sowerby 1996) have documented the importance of *Parthenium* as a potential source of herbicide. Allelochemicals are classified into 10 categories (Li et al. 2010) according to their different structures and properties:

1. Water-soluble organic acids, straight-chain alcohols, aliphatic aldehydes and ketones
2. Simple lactones
3. Long-chain fatty acids and polyacetylenes
4. Quinines (benzoquinone, anthraquinone and complex quinines)
5. Phenolics
6. Cinnamic acid and its derivatives
7. Coumarins
8. Flavonoids
9. Tannins
10. Steroids and terpenoids (sesquiterpene lactones, diterpenes and triterpenoids).

By composting: The *Parthenium hysterophorus* is a rich source of N, P, K, Ca, Mg and chlorophyll content and is ideally suited for composting, which is two times more than Farm Yard Manure (FYM) for this reason (Apurva et al. 2010). *Parthenium* compost aids in moisture conservation which is utilized for better root penetration and crop growth. This enhancement is attributed to the higher water holding capacity of the soil due to the influence of organic waste application. The moisture in the soil due to application of

Parthenium compost was 14.5 and 16.5% at 0-15 and 15-30 cm depths as compared to 10.7 and 11.6% at 0-15 and 15-30 cm depths of soil due to application of NPK alone (Ambasta & Kumari 2013). Finally, composting *Parthenium* before flowering is a means to minimize its allelopathic inhibition potential and one way of management by utilization.

Legal management: Laws and acts for the control of *Parthenium* at national level should be approved by the legislators. Administration of federal as well as provincial government, in collaboration with the scientists, should give a wide publicity through radio, T.V., video, posters and seminars to bring awareness and educate the people for the implementation of the laws and Acts.

PROBLEMS CREATED BY *PARTHENIUM*

Parthenium is considered as dangerous terrestrial weed because of its harmful effects on humans, animals and biodiversity, which are discussed below.

Impact on agricultural viability: *Parthenium* weed is becoming a weed of global significance and it is expanding its range not only within the already reported countries but it is also invading new ones (Shabbir 2011). Aqueous extracts of shoot, leaf, flower and root of *Parthenium* weed exhibited allelopathic effect on soybean and haricot bean seed germination, germination rate, shoot, root growth and dry matter production of seedlings (Netsere & Mendesil 2011). Maharjan et al. (2007) found that leaf aqueous extracts of *Parthenium hysterophorus* exhibited significant inhibitory effects on seed germination and seedling growth of three cereal crops i.e., *Oryza sativa*, *Triticum aestivum* and *Zea mays*; three crucifer vegetables i.e., *Raphanus sativus*, *Brassica campestris*, *Brassica oleracea* and two asteraceae species i.e., *Ageratina adenophora* and *Artemisia dubia*. Lethal allelopathic effects of the weed on many agricultural crops including chickpea, mustard and linseed have been reported (Oudhia et al. 1997, 2002b). Sorghum grain yield losses between 40 and 97% were reported in Ethiopia when *Parthenium* was left uncontrolled throughout the season (Tamado et al. 2002b). Accumulation of *Parthenium* pollen clusters on floral parts of maize cause 50% reduction in grain filling (Mahadebvappa 1997). Kumar & Kumar (2010) reported that increasing concentration of ash of *Parthenium* has adverse effect on germination, radical and plumule length of *Phaseolus mungo*. Therefore, burning of *Parthenium* in the agricultural field can reduce the productivity of *Phaseolus mungo*. In India, *Parthenium* weed causes yield losses of up to 40% in several crops (Khosla & Sobti 1979) and it is reported to reduce forage production by up to 90% (Nath 1981). In Queensland (Australia), the species has invaded 170,000 km^2 of high quality grazing areas and losses to the cattle industry (Gnanavel 2013). *Parthenium* weed seed is also a contaminant of grain, pasture and forage seeds. Hence, it results in restricted sale and movement of these produces. The weed is known to inhibit the growth and activity of nitrogen fixing bacterias like *Rhizobium* and *Azotobacter* and nitrifying bacteria like *Nitrosomonas*. The pollen deposition is reported to inhibit fruit or seed setting in crops like tomato, brinjal, beans, capsicum and maize (Yaduraju et al. 2005). Agricultural losses due to *Parthenium* are severe.

Impact on biodiversity: The weed *Parthenium* has also been identified in Faridpur, Norail, Magura, Rajshahi, Natore, Sirajgonj, Manikgonj, Dhaka and Mymensingh districts of Bangladesh (Karim & Farzwa 2010). The weed and rubber vine are considered to be the two weeds of greatest threat to biodiversity in the Einasleigh Uplands Bioregion (Sattler & Williams 1999). It has reported to cause a total habitat change in native Australian grasslands, open woodlands, river banks and flood plains (McFadyen 1992, Chippendale & Panetta 1994). *Parthenium* weed is a serious problem in perennial grasslands of Central Queensland (Adkins et al. 1996, Navie et al. 1996, 1998), where it can reduce the beef production by as much as Aus. $16.5 million annually. Very sparse or sometimes no other vegetation can be seen in *P. hysterophorus* dominated areas. Phytotoxins (allelochemicals) of *Parthenium* plant are released from the decomposing biomass and root exudates in the soil. The weed also acts as an alternate host for many diseases, notable being the diseases in sunflower and tomato. These weeds rapidly invade new surroundings often replace the indigenous species and pose a serious threat to biodiversity in India.

Impact on animal health: All parts of the *Parthenium* plant at any stage of growth are toxic to humans and animals (Anonymous 2004). The major component which cause toxicity is 'parthenin' and other phenolic acids such as caffeic acid, vanillic acid, anisic acid, p-anisic acid, chlorogenic acid and parahydroxy benzoic acid which are lethal to human beings and animals (Mahadevappa 1997, Oudhia 1998). It can taint sheep meat and make dairy milk unpalatable due to its irritating odour. When animals eat the *Parthenium* weed, their milk become bitter and when children drink this milk, it increases the secretion of intestine and decreases the absorption and they develop diarrhoea. If eaten by animals, it is responsible for mouth ulcers with excessive salivation. Significant amount (10-50%) of this weed in the diet can kill cattle (Narasimhan et al. 1977). In addition, it causes anorexia, pruritus, alopecia, diarrhoea and eye irritation in dogs. *Parthenium* also caused acute illness when it

was mixed with cattle fodder (Aneja1991).

Impact on human health: *Parthenium* weed has been shown to be related to health problems for some people living or working in close proximity to it. Individuals in contact with *Parthenium* can develop sensitivity to the plant, which may then manifest as an allergy-type response. Contact with any parts of the *Parthenium* plant (such as airborne pieces of dried plant material, pollen or even root) can cause the development of sensitivity as well as the subsequent risk of allergic reactions. Study by Wiesner et al. (2007) indicated that *Parthenium* causes general illness, asthmatic problems, irritation of skin and pustules on hand balls, stretching, cracking of skin and stomach pains in humans. Parthenin is the major sesquiterpene lactone present in the weed *Parthenium* growing in India. Around three decades ago, serious human health risks from *P. hysterophorus* were reported from Pune (Lonker et al. 1974). A survey in Queensland showed 10 per cent of property workers in infested areas had developed visible allergic symptoms to *Parthenium* (Chippendale & Panetta 1994). The clinical progression of *Parthenium* dermatitis indicated that the severity of a reaction might worsen over time leading to chronic acute dermatitis (Sharma et al. 2005). An increase in parthenin concentration with plant age was observed by Reinhardt et al. (2006) with highest levels occurring in the final three growth stages viz., at the beginning of leaf development to flowering in all leaf axils, flowers buds formed in all axils to fruit development, ripening/maturity of fruits and seeds, for both fresh and dry mass of plant as well as for overall parthenin content in all leaf material. High levels of parthenin have also been reported in the flowers and achenes of *Parthenium* (Rodriguez et al. 1975, Picman et al. 1979). These additional sources of parthenin will boost the potential quantity of parthenin that could be released into the environment. At senescence, plants were found to contain parthenin content of 270 mg (Reinhardt et al. 2006). Leaves and inflorescence contain highest amount of parthenin followed by stem and roots, while total phenolics were found to be highest in leaves followed by inflorescence, roots and stem. Contact of plant with the body causes dermatitis and the spread of problem all over the body causes great discomfort (Wiesner et al. 2007). Clinically, the *Parthenium* dermatitis are of three types, as discussed below:

1. The classical pattern, also known as Air Borne Contact Dermatitis (ABCD) affects the face, especially eyelids and/or neck, V of chest, cubital and popliteal fossae.
2. The Chronic Actinic Dermatitis (CAD) pattern involves the exposed areas such as forehead, rim of ears, cheeks, nape of neck, dorsae of forearms and hands as lichenified papules, plaques or papulo nodules with relative sparing of non-sun exposed areas such as eyelids, retro-auricular areas and under surface of chin and depth of the skin folds.
3. The mixed pattern (combination of classical and CAD pattern) manifests as scattered infiltrated scaly papules over the exposed parts and dermatitis over eyelids, flexures of extremities and neck.

ECONOMIC IMPORTANCE OF *PARTHENIUM*

Parthenium is spreading at an alarming rate all over India (Kumar et al. 2009) and can adopt any climate very easily. In West Indies, this weed is used as a remedy against ulcerated sores, certain skin disease, facial neuralgia, fever and anaemia (Bhatt et al. 2012). Inflammation, eczema, skin rashes, herpes, rheumatic pain, cold heart trouble, menstrual disorders, difficulty during labour, stomach ache, toothache, diarrhoea, neurologic disorders, urinary infections, dysentery, malaria and insect bites are also treated (Barnes et al. 2007, Patel 2011). A preparation with ginger is effective for treating migraines during the early pain phase (Kuhn & Winston 2007). Its broad-spectrum ovicidal, antimicrobial, larvicidal, nematocidal, herbicidal activities designate the improvement of public health and crop production (Bhatt et al. 2012). It is also used as an additive with cattle manure in biogas production (Patel 2011).

CONCLUSION

The noxious *P. hysterophorus* grows in a wide variety of habitats and cause changes in above ground vegetation as well as in below ground soil nutrients. It is capable of outcompeting native and non-native palatable plants that are important to livestock. Furthermore, the change in vegetation and soil nutrients could lead to ultimate change in other trophic levels and alter the function of the ecosystem. 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 it inherits various insecticidal, antifeedant, nematicidal, herbicidal antifungal, antiamoebic, antimalarial, trypanocidal, antibacterial and antiviral properties. The problem of wide spreading of *Parthenium* constitutes a major constraint to biodiversity, agriculture as well as human health. Increased efforts must be put in place to elaborate control strategies that are efficient and easy to use. Mechanical, chemical and biological control strategies have been proved futile individually to curb proliferation of *P. hysterophorus*. So, integrated approaches are suggested to restrict the invasion of this weed. To address this problem, public awareness has to be devel-

oped and participatory approach to control the invasive weeds should be adopted. The following intensive awareness creation and collaborative activities are also suggested:

- Developing a participative approach for the control and management of *Parthenium.*
- Promoting new *Parthenium* research gathered via appropriate innovative and existing extension networks.
- Establishing *Parthenium* Action Groups both at Federal and Regional level, the aims of which are to eradicate or contain the weed.
- Developing and testing an appropriate participatory methodology for *Parthenium* management.
- Identifying effective information dissemination techniques to build awareness.
- Identifying novel approaches required to develop action by stakeholders with *Parthenium* in urban and rural areas.
- Studying the potential use of *Parthenium.* Information is available that it can be used for many purposes: Greenleaf manure, compost, biopesticide and soil amendment.

Appropriate methods for the management of *P. hysterophorus* are necessary to avoid potential threats to biodiversity and economic losses. No single method alone has been effective in its management. Therefore, an integrated weed management approach seems to be the only effective method that is likely to produce promising results. Nevertheless, the weed has not been completely checked and still creating nuisance both in India and Australia, and more efforts are required by scientists, agriculturists and government to work jointly for managing this troublesome weed.

REFERENCES

Adkins, S.W., Naïve, S.C. and McFadyen, F.E. 1996. Control of *Parthenium* weed (*Parthenium hysterophorus* L.): A centre for tropical pest management team effort. In: Proc. Eleventh Aust. Weed Confr. Melbourne, Australia.

Ajmal, M., Rao, R.A.K., Ahmad, R. and Khan, M.A. 2006. Adsorption studies on *Parthenium hysterophorous* weed: Removal and recovery of Cd(II) from wastewater. J. Haz. Mat. B., 135: 242-248.

Ambasta, S.K. and Kumari, S. 2013. A scientific approach of conversion of eco-hazardous *Parthenium* weed into eco-friendly by compost making. Intl. J. Geo. Earth Environ. Sci., 3(1): 90-94.

An, M., Pratley, J. and Haig, T. 1998. Allelopathy: From concept to reality. In: Proceedings of the 9th Australian Agronomy Conference, Charles Sturt University Convention Centre, http://www.regional.org.au/au/asa/1998.

Aneja, K.R. 1999. Biotechnology for the production and enhancement of mycoherbicide potential. In: From Ethnomycology to Fungal Biotechnology, UK: Plenum Publishers., pp. 91-114.

Aneja, K.R. 1991. Deadly weed *Parthenium hysterophorus* and its control-a review. In: Botanical Researches in India, Himanshu Publications, Udaipur, pp. 258-269.

Anonymous 2004. Parthenium weed: Ecology threat. In: Parthenium Weed Management-Challenges, Opportunities and Strategies. The Director of Product Marketing, Department of Natural Resources, Mines and Energy, The State of Queensland, Australia, pp. 1-9.

APFISN (Asia-Pacific Forest Invasive Species Network) report on *Parthenium hysterophorus* compiled and edited by Dr. K.V. Sankaran, APFISN Coordinator, Kerala Forest Research Institute, Peechi, Kerala, India (sankaran@kfri.org).

Apurva, P., Sinha, S.K. and Thakur, P.C. 2010. Composting an obnoxious weed, *Parthenium hyterophorous* L., with the help of a millipede, *Harpaphe haydeniana*. Asian J. Exp. Biol. Sci., 1(2): 337-343.

Australian Weeds Committee 2012. Parthenium (*Parthenium hysterophorus* L.) strategic plan 2012-17, Weeds of National Significance, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra.

Bala, S.K., Bhattacharya, P., Mukerjee, K.S. and Sukul, N.C. 1986. Nematicidal properties of the plants *Xanthium strumarium* and *Parthenium hysterophorus*. Environ. Ecol., 4: 139-141.

Barnes, J., Anderson, L.A. and Phillipson, J.D. 2007. Herbal Medicines. The Pharmaceutical Press, RPS Publishing, London, UK.

Bhan, V.M., Kumar, S. and Raghuwanshi, M.S. 1997. Future strategies for effective *Parthenium* management. In: Proc. First Int. Conf. on *Parthenium* Management, pp. 90-95.

Bhatt, J.R., Singh, J.S., Singh, S.P., Tripathi, R.S. and Kohli, R.K. 2012. Invasive Alien Plants: An Ecological Appraisal for the Indian Subcontinent, CABI.

Boon, H. and Smith, M. 2004. The Complete Natural Medicine Guide to 50 Most Common Medicinal Herbs, Robert Rose.

Chippendale, J.F. and Panetta, FD. 1994. The cost of *Parthenium* weed to the Queensland cattle industry. Plant Protect Quart., 9: 73-76.

Das, B., Reddy, V.S., Krishnaiah, M., Sharma, A.V.S., Ravi Kumar, K., Rao, J.V. and Sridhar, V. 2007. Acetylated pseudoguaianolides from *Parthenium hysterophorus* and their cytotoxic activity. Phytochemistry, 68: 2029-2034.

Datta, S. and Saxena, D.B. 2001. Pesticidal properties of parthenin (from *Parthenium hysterophorus*) and related compounds. Pest Manag. Sci., 57: 95-101.

Dhileepan, K. 2001. Effectiveness of introduced biocontrol insects on the weed *Parthenium hysterophorus* (Asteraceae) in Australia. Bulletin of Entomological Reseach, 91(03): 167-176.

Duke, S.O., Dayan, F.E., Aliota, G. and Rongani, I.G. 2002. Chemicals form nature for weed management. Weed Sci., 50: 138-151.

Dwivedi, P., Vivekanand, V., Ganguly, R. and Singh, R.P. 2009. *Parthenium* sp. as a plant biomass for the production of alkali tolerant xylanase from mutant *Penicillium oxalicum* SAUE-3.510 in submerged fermentation. Biomass Energy, 33: 581-588.

El-Sayed, W. 2005. Review biological control of weeds with pathogens: Current status and future trends. Journal of Plant Disease Protection, 112(3): 209-221.

Gaikwad, C.B., Kasture, M.C. and Lambade, B.M. 2008. Evaluation of herbicides for control of *Parthenium* in waste land. Indian Journal of Weed Science, 40: 79-81.

Gaikwad, C.B. 2006. Large Scale Demonstration of *Parthenium* Management Through Integrated Approches. Second Annual Report, D.B.T. Funded Project., 57.

Gajendran, G. and Gopalan, M. 1982. Notes on the antifeedant activity of *Parthenium hysterophorus* L. on *Spodoptera litura*. Ind. J. Agric. Sci., 52: 203-205.

Gautam, R.D., Khan, M.D., Aslam Samyal, A., Garg, A.K.,

Mahadevappa, M. and Sharma, R. 2005a. Survey of the plants suppressing *Parthenium hysterophorus* Linnaeus in Delhi. In: Proceedings of Second International Conference on *Parthenium* Management held at Bangalore (Karnataka), 5-7 December 2005, pp. 94-97.

Gnanavel, I. 2013. *Parthenium hysterophorous* L.: A major threat to natural and agro ecosystem in India. Science International, 1(5): 124-131.

Gniazdowska, A. and Bogatek, R. 2005. Alleopathic interaction between plants. Multiside action of allelochemicals. Acta Physiologiae Plantarum, 27(3): 395-407.

Gunaseelan, V.N. 1987. Parthenium as an additive with cattle manure in biogas production. Biol. Wastes, 21: 195-202.

Gupta, N., Martin, B.M., Metcalfe, D.D. and Rao, P. V. 1996. Identification of a novel hydroxyproline-rich glycoprotein as the major allergen in *Parthenium* pollen. The Journal of Allergy and Clinical Immunology, 98: 903-912.

Holm, L., Doll, J., Holm, E., Pancho, J.V. and Herberger, J. 1997. World Weeds: Natural Histories and Distribution. John Wiley & Sons, New York, NY, USA.

Iqbal, M.F., Hussain, M., Abid, A.H., Ali, M.A., Iqbal, Z., Waqar, M.Q. and Iram, A. 2014. A review: Parthenium (*Parthenium heterosphorus* L.) major threat in Gujranwala. Int. J. Adv. Res. Biol. Sci., 1(4): 38-41.

Javaid, A. and Shah, M.B.M. 2008. Use of Parthenium weed as green manure for maize and mungbean production. Philipp. Agric. Sci., 91(4): 478-482.

Javaid, A., Anjum, T. and Bajwa, R. 2005. Biological control of *Parthenium* II: Allelopathic effect of *Desmostachya bipinnata* on distribution and early seedling growth of *Parthenium hysterophorus* L. International Journal of Biology and Biotechnology, 2(2): 459-463.

Javaid, A. 2007. Efficacy of some chemical herbicides against *Parthenium hysterophorus* L. Pakistan Journal of Weed Science Research, 13: 93-98.

Jayanth, K. P. 1997. Introduction and establishment of *Zygogramma bicolorata* on *Parthenium hysterophorus* at Bangalore, India. Current Science, 40: 568-569.

Joshi, S. 1991. Interference effect of *Cassia uniflora* Mill. on *Parthenium hysterophorus* L. Plant Soil, 132: 213-218.

Kandasamy, O. S. and Sankaran, S. 1997. Biological suppression of Parthenium weed using competitive crops and plants. In: Proceeding of the First International Conference on Parthenium Management. University of Agricultural Sciences, Dahrwad, India, pp. 33-36.

Karim, S.M.R. and Forzwa, R. 2010. Allelopathic effects of Parthenium weed on the seed germination and seedling growth of field crops. Abstract, Annual Botanical Conference 2009, held at Chittagong University, Bangladesh, pp. 38-39.

Kaur Manpreet, Aggarwal Neeraj Kumar, Vikas Kumar and Dhiman Romika 2014. Effects and management of *Parthenium hysterophorus*: A weed of global significance. International Scholarly Research Notices, Hindawi Publishing Corporation, 2014, pp. 1-12.

Kauraw, L.P., Chile, A. and Bhan, V.M. 1997. Evaluation of *Fusarium pallidoroseum* (Cooke) Sacc. for the biocontrol of *Parthenium hysterophorus* L. In : Proceedings of First International Conference on Parthenium Management, 6-8 October 1997, Dharwad, India, Vol. II, pp. 70-74.

Khosla, S.N. and Sobti, S. N. 1981. Effective control of *Parthenium hysterophorus* L. Pesticides., 15: 18-19.

Kishor, P., Ghosh, A.K., Singh, S. and Maury, B.R. 2010. Potential use of Parthenium (*Parthenium hysterophorus* L.) in agriculture. Asian J. Agric. Res., 4: A220-225.

Knox, J. 2008. An Investigation on Suppressing Capabilities of Some Allelopathic Plants Against *Parthenium hysterophorus* L., Ph.D Thesis, Dr. B.R. Ambedkar University, Agra, India.

Kohli, R.K., Batish, D.R., Singh, H. and Dogra, K.S. 2006. Status, invasiveness and environmental threats of three tropical American invasive weeds (*Parthenium hysterophorus* L., *Ageratum conyzoides* L., *Lantana camara* L.) in India. Biological Invasions, 8(7): 1501-1510.

Kumar, M. and Kumar, S. 2010. Effect of *Parthenium hysterophorus* ash on growth and biomass of *Phaseolus mungo*. Academia Arena, 2(1): 98-102.

Kumar, S. and Varshney, J.G. 2008. Successful biological control of water hyacinth (*Eichhornia crassipes*) through weevil *Neochetina* spp. in ponds of Jabalpur, MP. Abstracts of 12th World Lake Conference, Jaipur, 28-October to 2-November, 5.

Kumar, S., Kasthuri, H., Prabha, D., Senthilkumar, P., Subbhuraam, C.V. and Song, Y.C. 2009. Efficiency of composting Parthenium plant and neem leaves in the presence and absence of an oligochaete, Eisenia fetida, Iran. J. Environ. Health. Sci. Eng., 6(3): 201-208.

Kumari, A., Kohli, R.K. and Saxena, D.B. 1985. Allelopathic effects of *Parthenium hysterophorus* leachates and extracts on *Brassica campestris* L. Annals Biol., 1: 189-196.

Lakshmi, C. and Srinivas, C.R. 2007. Parthenium: A wide angle view. Ind. J. Dermatol. Venereol. Leprol., 73: 296-306.

Lakshmi, C. and Srinivas, C.R. 2007. Type I hypersensitivity to *Parthenium hysterophorus* in patients with *Parthenium* dermatitis. Indian Journal of Dermatology Venereology and Leprology, 73(2): 103.

Lata, H., Garg, V.K. and Gupta, R.K. 2008. Sequestration of nickel from aqueous solution onto activated carbon prepared from *Parthenium hysterophorus* L. J. Haz. Mat., 157: 503-509.

Li, Z. H., Wang, Q., Ruan, X., Pan, C. D. and Jiang, D. A. 2010. Phenolics and plant allelopathy. Molecules, 15(12): 8933-8952.

Lonkar, A., Mitchell, J.C. and Calnan, C.D. 1974. Contact dermatitis from *Parthenium hysterophorus*. Transactions of the St. John's Hospital Dermatological Society, 60(1): 43-53.

Mahadevappa, M. 1997. Ecology, distribution, menace and management of Parthenium. In: Proc. First International Conference on Parthenium Management, 1: 1-12.

Maishi, A.I., Ali, P.K.S., Chaghtai, S.A. and Khan, G. 1998. A proving of *Parthenium hysterophorus* L. Brit. Homoeopath. J., 87: 17-21.

Mane, J.D., Jadav, S. J. and Ramaiah, N.A. 1986. Production of oxalic acid from dry powder of *Parthenium hysterophorus* L. J. Agric. Food Chem., 34: 989-990.

McFadyen, R.E. 1992. Biological control against Parthenium weed in Australia. Crop Protec., 11: 400-407.

Mishra, J. S. and Bhan, V. M. 1994. Efficacy of sulfonyl urea herbicides against *Parthenium hysterophorus*. Weed News., 1: 16.

Molisch, H. 1937. Der Einfluss einer Pflanze auf die andere-Allelopathie. Fischer, Jena.

Monaco, J.T., Weller, S.C. and Ashton, F.M. 2001. Weed biology and ecology, Fourth ed., Academic Publisher, USA.

Narasimhan, T.R., Ananth, M., Mangala, A. and Rao, P.V.S. 1977. Toxicity of *Parthenium hysterophorus* L. Curr. Sci., 46: 15-16.

Narasimhan, T.R., Ananth, M., Swamy, M.N., Babu, M.R., Mangala, A. and Rao, P. S. 1977. Toxicity of *Parthenium hysterophorus* L. to cattle and buffaloes. Experientia, 33(10): 1358-1359.

Nath, R. 1981. Note on the effect of *Parthenium* extract on seed germination and seedling growth in crops. Indian J. Agric. Sci., 51.

Navie, S.C., McFadyen, R.E. Panetta, F.D. and Adkins, S.W. 1996.

The biology of Australian weeds. 27. *Parthenium hysterophorus* L. Plant Protect., 11: 76-88.

Netsere, A. and Mendesil, E. 2011. Allelopathic effects of *Parthenium hysterophorous* L. aqueous extracts on soybean (*Glycine max* L.) and haricot bean (*Phaseolus vulgaris* L.) seed germination, shoot and root growth and dry matter production. J. Appl. Bot. Food Qual., 84: 219-222.

Oudhia, P., Kolhe, S.S. and Tripathi, R.S. 1997. Allelopathic effect of white top (*Parthenium hysterophorus* L.) on chickpea. Legume Res., 20(2): 117-120.

Oudhia, P. 1998. Parthenium: A curse for the biodiversity of Chhattisgarh plain. In: Abstract, National Research Seminar on Biochemical Changes, An Impact on Environment, R.D. Govt. P.G. College, Mandla (M.P.), p. 6.

Pandey, D.K. 1994. Inhibition of salvinia (*Salvinia molesta* Mitchell) by Parthenium (*Parthenium hysterophorus* L.). I. Effect of leaf residue and allelochemicals. J. Chem. Biol., 19: 2651-2662.

Pandey, D.K., Kauraw, L.P. and Bhan, V.M. 1993. Inhibitory effect of *Parthenium hysterophorus* residue on growth of water hyacinth (*Eichhornia crassipes*). J. Chem. Ecol., 19: 2651-2662.

Parashar, V., Parashar, R., Sharma, B. and Pandey, A. 2009. Parthenium leaf extract mediated synthesis of silver nano particles: A novel approach towards weed utilization. Digest J. Nanomater. Biostruct., 4: 45-50.

Pareek, A., Suthar, M., Rathore, G.S. and Bansal, V. 2011. Feverfew (*Tanacetum parthenium* L.): A systematic review. Pharmacognosy Review, 5: 103-110.

Parsons, W.T. and Cuthbertson, E.G. 2001. Noxious Weeds of Australia. CSIRO Publishing.

Parsons, W.T. and Cuthbertson, E.G. 1992. Noxious Weeds of Australia. Inkata Press, Melbourne.

Patel, S. 2011. Harmful and beneficial aspects of *Parthenium hysterophorus*: An update. 3 Biotech., 1: 1-9.

Patel, V.S., Chitra, V.P., Prasanna, L. and Krishnaraju, V. 2008. Hypoglycemic effect of aqueous extract of *Parthenium hysterophorus* L. In normal and alloxan induced diabetic rats. Ind. J. Pharmacol., 40: 183-185.

Picman, A.K., Rodriguez, E. and Towers, G.H.N. 1979. Formation of adducts of parthenin and related sesquiterpenel actones with cysteine and glutathione. Chemico Biological Interactions, 28: 83-86.

Rajeshwari, S. and Subburam, V. 2002. Activated Parthenium carbon as an adsorbent for the removal of dyes and heavy metal ions from aqueous solution. Bioresour. Technol., 85: 205-206.

Ramos, A., Rivero, R., Visozo, A., Piloto, J. and Garcia, A. 2002. Parthenin, a sesquiterpene lactone of *Parthenium hysterophorus* L. is a high toxicity clastogen. Mut. Res., 514: 19-27.

Ray, P. and Gour, H.N. 2012. Integrated management of *Parthenium hysterophorus* L. (Asteraceae): A weed of worldwide significance. Indian Society of Mycology and Plant Pathology, 5: 605-632.

Reinhardt, C., VanderLaan, M., Belz, R.G., Hurle, K. and Foxcroft, L. 2006. Production of the allelochemical parthenin in leaves of *Parthenium hysterophorus* L. Journal of Plant Diseases and Protection: XX: 427-433.

Rodriguez, E. 1975. The Chemistry and Distribution of Sesquiter Penelactones and Flavonoides in Parthenium (Compositae): Systematic Andecological Implications. Ph.D. Thesis, University of Texas.

Roy, D.C. and Shaik, M.M. 2013. Toxicology, phytochemistry, bioactive compounds and pharmacology of *Parthenium hysterophorus*. Journal of Medicinal Plants Studies, 1(3): 126-141.

Sankaran, K. V. 2011. *Parthenium heterosporous* (Carrot weed): Invasive pest fact sheet. Kerala Forest Research Institute, Peechi, Kerala, India.

Sarkate, M.B. and Pawar, V.M. 2005. Establishment of Mexican beetle (*Zygogramma bicolorata*) Pallister in biological suppression of *Parthenium hysterophorus* in Maharashtra. In: Proceedings of Second International Conference on Parthenium Management held at Bangalore (Karnataka), pp. 120-122.

Sattler, P. and Williams, V. 1999. The conservation status of Queensland's bioregional ecosystems. Queensland Environmental Protection Agency.

Shabbir, A. 2014. Chemical control of *Parthenium hysterophorous* L. Pak. J. Weed Sci. Res., 20(1): 1-10.

Shabbir, A. 2012. Towards the improved management of Parthenium weed: Complementing biological control with plant suppression. Ph.D. Thesis, School of Agriculture and Food Sciences, University of Queensland.

Sharma, V.K., Sethuraman, G. and Bhat, R. 2005. Evolution of clinical pattern of Parthenium dermatitis: A study of 74 cases. Contact Dermatitis, 53.

Singh, R.K., Kumar, S., Kumar, S. and Kumar, A. 2008. Development of Parthenium based activated carbon and its utilization for adsorptive removal of p-cresol from aqueous solution. J. Haz. Mat., 155: 523-535.

Srivastava, J.N., Shukla, J.P. and Srivastava, R.C. 1985. Effect of *Parthenium hysterophorus* extract on the seed germination and seedling growth of barley, pea and wheat. Acta. Bot. Indica, 13: 194-197.

Stephen, W.A. and Sowerby, M.S. 1996. Allelopathic potential of the weed, *Parthenium hysterophorus* L. in Australia. Plant Protection, 11: 20-23.

Surib-Fakim, A., Swerab, M.D., Gueho, J. and Dullo, E. 1996. Medicinal plants of Rodrigues. Int. J. Pharmacogn., 34: 2-14.

Tamado, T., Schutz, W. and Milberg, P. 2002b. Germination ecology of the weed *Parthenium hysterophorus* in Eastern Ethiopia. Ann. Appl. Biol., 140(3): 263-270.

Tefera, T. 2002. Allelopathic effects of *Parthenium hysterophorus* extracts on seed germination and seedling growth of *Eragrostis* tef. J. Agron. Crop Sci., 188: 306-310.

Venkataiah, B., Ramesh, C., Ravindranath, N. and Das, B. 2003. Charminarone, a seco-pseudoguaianolide from *Parthenium hysterophorus*. Phytochemistry, 63: 383-386.

Watson, A.K. and Wymore, L.A. 1990. Identifying limiting factors in the biocontrol of weeds. In: New Directions in Biological Control: Alternatives for Suppressing Agricultural Pests and Diseases, Academic Press, New York, pp. 305-316.

Wiesner, M., Taye, T., Hoffmann, A., Wilfried, P., Buettner, C., Mewis I. and Ulrichs, C. 2007. Impact of the Pan-Tropical weed *Parthenium hysterophorus* L. on human health in Ethiopia. Utilisation of diversity in land use systems: Sustainable and organic approaches to meet human needs. Tropentag, October 9-11, Witzenhausen.

Wiesner, M., Tessema, T., Hoffmann, A., Wilfried, P., Buettner, C., Mewis, I. and Ulrichs, C. 2007. Impact of the pan-tropical weed *Parthenium hysterophorus* L. on human health in Ethiopia. Institute of Horticultural Science, Urban Horticulture, Berlin, Germany.

Williams, J.D. and Groves, R.H. 1980. The influence of temperature and photoperiod on growth and development of *Parthenium hysterophorus*. Weed Res., 20: 47-52.

Yaduraju, N.T., Sushilkumar, Prasad Babu, M.B.B. and Gogoi, A.K. 2005. *Parthenium hysterophorus* - Distribution, problem and management strategies in India. In : Proceedings of Second International Conference on Parthenium Management, held at Bangalore (Karnataka), 6-10.

Zhou, J., Xie, G. and Yan, X. 2011b. Encyclopedia of Traditional

Chinese Medicines-Molecular Structures, Pharmacological Activities, Natural Sources and Applications, 5: Isolated Compounds T-Z, References, TCM Plants and Congeners, Berlin, Heidelberg, Springer Berlin Heidelberg.

Zhou, J., Xie, G. and Yan, X. 2011c. Encyclopedia of Traditional Chinese Medicines - Molecular Structures, Pharmacological Activities, Natural Sources and Applications, 2: Isolated Compounds D-G (Springer).

Zhou, J., Xie, G. and Yan, X. 2011d. Encyclopedia of Traditional Chinese Medicines-Molecular Structures, Pharmacological Activities, Natural Sources and Applications, 3: Isolated Compounds H-M (Springer).

Zhou, J., Xie, G. and Yan, X. 2011e. Encyclopedia of Traditional Chinese Medicines-Molecular Structures, Pharmacological Activities, Natural Sources and Applications, 4: Isolated Compounds N-S (Springer).

Zhou, J., Xie, G. and Yan, X. 2011f. Encyclopedia of Traditional Chinese Medicines: Molecular Structures, Pharmacological Activities, Natural Sources and Applications. Isolated Compounds A-C (Springer).