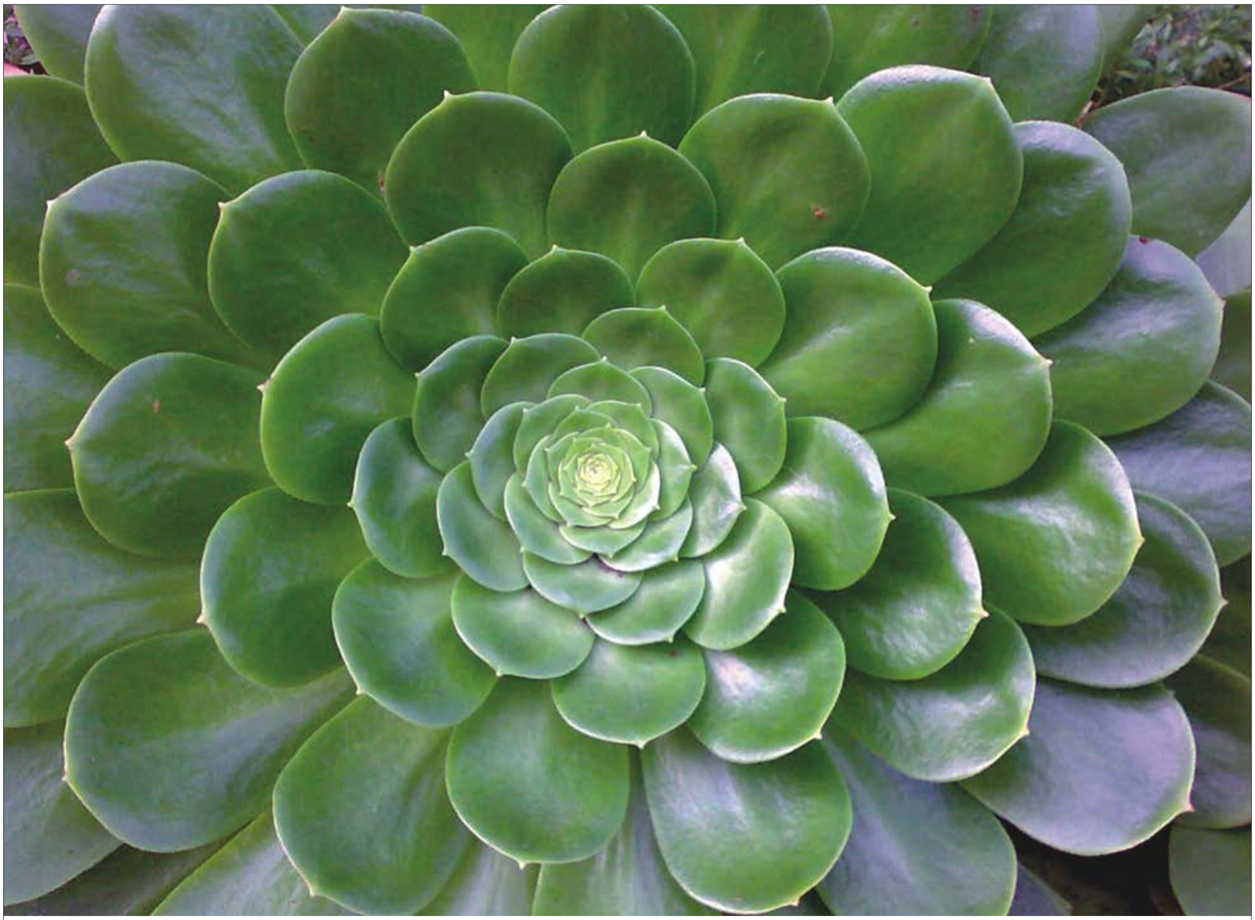

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Parthenium hysterophorus in Current Scenario: A Toxic Weed with Industrial, Agricultural and Medicinal Applications

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ABSTRACT
Parthenium hysterophorus is an aggressive weed being invasive with allelopathic effect, it poses a serious threat to the environment and biodiversity. It adversely affects grazing animals and human beings, which directly or indirectly comes in contact with this weed. All ways to control it are not fully successful. However, recent reports suggest its medicinal uses as antidiabetic, antioxidant, antitumor and antimalarial which can be explored for human use after scientific trials. It is also a rich source of minerals like N, P, K, Fe, Mn, Cu and Zn which also makes it useful for agriculture. Uprooted *Parthenium* before fruiting can be used as easily available, cheap and nutrient rich compost. *Parthenium* can also be used as a potent herbicide, insecticide, pesticide and phytoremedial agent for metal and dye removal from industrial waste. As, *Parthenium* has various beneficial and harmful effects so, it should be used after thorough research.

Key words: *Parthenium hysterophorus* L, allelopathic, antioxidant, compost, herbicide

INTRODUCTION
Parthenium hysterophorus (Asteraceae) is commonly known as carrot weed, white top, ragweed parthenium, chatak chandani, congress grass and star weed. The taxonomic classification of congress grass is as follows (ITIS., 2010):

Division	:	Tracheophyta
Class	:	Magnoliopsida
Order	:	Asterales
Family	:	Asteraceae

Parthenium hysterophorus (*P. hysterophorus*) is a prolific seed producer and widely distributed in Asia and Europe. In India, *Parthenium* weed was first described in 1810 but emerged as a serious problem after 1955, when it was introduced in contaminated cereal grains (Rao, 1956). Since then, it has spread like wildfire throughout India and presently occupies over 5 million hectare land (Kumar and Kumar, 2010). *Parthenium hysterophorus* seed germination takes place over a broad range of fluctuating (12/2-35/25°C) temperatures (Tamado *et al*., 2002). The weed prefers alkaline to neutral clayey soils for its growth (Mahadevappa, 1997).

Occurrence of *P. hysterophorus* negatively affects the diversity and composition of range land vegetation by depleting wealth of natural plant species in affected areas (Ayele, 2007).

Allelochemicals production by the plants assists to regulate the soil microflora in their vicinity, physiochemical properties of their immediate surrounding environment and growth of competing plant species (Pedrol *et al.,* 2006). It is feared that rapid and unregulated expansion of this weed may threaten the carrying capacity of grazing land. *Parthenium hysterophorus* not only adversely affects the plants but also humans and grazing animal's health (Towers and Rao, 1992). This review mainly focuses on effect of congress grass on human beings, grazing animals and plants along with its possible use in therapeutics, industry and agriculture. As, its control is also being a major concern for scientists, so weed control measures are also discussed in present review.

Harmful effects of *Parthenium hysterophorus*

Human health: *Parthenium hysterophorus* caused health problems like bronchitis, dermatitis, asthma and hay fever (Kologi *et al*., 1997) (Table 1). Parthenin and additional phenolic acids viz. caffeic acid, anisic acid, vanillic acid, chlorogenic acid, panisic acid and parahydroxy benzoic acids are the major components responsible for lethality to human beings and grazing animals (Mahadevappa, 1997). Allergic eczematous, contact dermatitis and depression in humans coming in contact with this weed has also been witnessed (Oudhia and Tripathi, 1997; Ayele, 2007).

Clinical progression of *P. hysterophorus* induced dermatitis worsens with time and finally leads to chronic actinic dermatitis. Furthermore, weed's pollens in the air cause induction of allergic rhinitis also called hay fever (Rao *et al*., 1985; Ayele, 2007). Pollens comprised 44% of the total pollen load during June to September (Seetharamiah *et al*., 1981; Ayele, 2007) in weed infested areas. The inhalation of pollens through breathing can cause allergic trinities and speed up the development of bronchitis or asthma (Evans, 1997; Ayele, 2007).

Parthenium hysterophorus also causes the formation of many reactive toxic compounds such as sesquiterpene lactones, which becomes the basis of weed dermatitis in India and USA (Towers and Rao, 1992). Regular exposure to *P. hysterophorus* resulted in dermatitis in about 15% of individuals and another 7-15% developed respiratory problems (McFadyen, 1992). Respiratory problems generally start with high fever and after 3-5 years of gradual exposure, respiratory problems become more severe as resulted into asthma and allergic bronchitis (Ayele, 2007).

Grazing animals: In pastures, the weed can put the livestock at risk, lower their productivity by reducing the quality and quantity of forage (Klingman and Ashton, 1982; Ayele, 2007) and also affects health, milk and meat quality of grazing animals (Evans, 1997).

Table 1: Harmful effects of *Parthenium hysterophorus*

Effects	Features	References
Adverse effects on health	Allergic bronchitis, dermatitis, asthma, hay fever, Allergic eczematous, depression in humans	Kologi *et al.* (1997), Oudhia and Tripathi (1997) and Ayele (2007)
	Erythematous eruptions, alopecia and skin depigmentation, edema, anorexic and dermatitis, meat taint, Tainting of milk in grazing animals	Evans (1997), Qureshi *et al.* (1980), Tudor *et al.* (1982), Ahmed *et al.* (1988), Towers and Rao (1992) and Ayele (2007)
Allopathic effect	Cereal crops (*Triticum aestivum* L., *Oryza sativa* L. and *Zea mays* L.) Crucifers (*Brassica oleracea* L., *Brassica campestris* L. and *Raphanus sativus* L.) Legumes (*Acacia catechu*, *Achyranthes aspera*, *Cassia tora, Vigna mungo*, *Vigna radiata*, *Cicer arietinum* and *Vigna unguiculata*) Astreaceae members (*Artemisia dubia* and *Ageratina adenophora*) *A. conyzoides, Helianthus annuus*, *Phaseolus vulgaris, Abelmoschus esculentus*, *Capsicum annuum* and *Trifolium repens*	Singh *et al.* (2005), Singh (2005), Verma and Rao (2006), Maharjan *et al.* (2007) and Dogra and Sood (2012)

Buffalo and crossbred calves fed on *P. hysterophorus*, developed toxic signs of erythematous eruptions, alopecia, skin depigmentation and edema (Table 1). Continuous feeding of aerial parts of *P. hysterophorus* upto 12 weeks cause anorexic and dermatitis in adult nanny goats (*Osmanabadi*) (Qureshi *et al*., 1980; Ahmed *et al*., 1988; Ayele, 2007). The meat was tainted in sheep fed on a diet having 30% *P. hysterophorus* (Tudor *et al*., 1982; Ayele, 2007). Tainting of milk was also reported in cows fed on *P. hysterophorus* (Towers and Rao, 1992; Ayele, 2007).

Ensilation can be used for removing toxic allelochemicals like parthenin, a major sesquiterpene lactone. After ensilation, silage made either from *P. hysterophorus* alone or *P. hysterophorus* mixed with *Zea mays* for animal feeding which did not produce any harmful effects in animals as confirmed by biochemical, physiological and hematological studies. As, the nutritive value of *Parthenium* silage is favorably comparable with standard diet and *Parthenium* seeds collected from the silage did not germinate (Narasimhan *et al*., 1984). Thus, ensilation can be effectively used for reducing toxicity of this weed. Processed weed can be used for animal feed and also for other purposes (Ayele, 2007).

Allelopathy in crops: Allelopathy of *P. hysterophorus* is well studied on cereal crops (*Triticum aestivum* L., *Oryza sativa* L. and *Zea mays* L.), crucifers (*Brassica oleracea* L., *Brassica campestris* L. and *Raphanus sativus* L.), legumes (*Acacia catechu*, *Achyranthes aspera*, *Cassia tora, Vigna mungo*, *Vigna radiata*, *Cicer arietinum* and *Vigna unguiculata*) and two wild species belonging to family Asteraceae (*Artemisia dubia* and *Ageratina adenophora*) and *A. conyzoides*. *Helianthus annuus*, *Phaseolus vulgaris, Abelmoschus esculentus*, *Capsicum annuum* and Trifolium repens (Singh *et al*., 2005; Verma and Rao, 2006; Maharjan *et al*., 2007; Dogra and Sood, 2012) (Table 1).

Germination and yield of traditional Indian pulse crops reduced, when grown in soils previously infested with *Parthenium* weed. Allelochemicals of *P. hysterophorus* like parthenin, caffeic acid and p-coumaric acid mediated the primary inhibitory effect (Kanchan and Jayachandra, 1980). Ash content (>3%) of *P. hysterophorus* also adversely affect germination, radicle and plumule length and biomass of *Phaseolus mungo* (Kumar and Kumar, 2010). Burning of *P. hysterophorus* should be avoided in the *Phaseolus mungo* fields to avoid adverse effects of weed.

Leaf extract of *P. hysterophorus* (>3, >6 and 10%), completely inhibited the seed germination of all crucifer species, *Triticum aestivum, Ageratina adenophora, Oryza sativa* and *Artemisia dubia*, respectively. Seed germination of *Zea mays* was adversely affected but not completely inhibited at higher concentration of leaf extract. The leaf extract also strongly inhibited root elongation in the seedling of cereals, shoot elongation in crucifers and wild species of *Asteraceae*. These studies indicated the presence of growth-retarding water soluble sesquiterpene lactones and phenolics or other allelochemicals (Singh, 2005).

Parthenin was the major sesquiterpene lactone involved, whereas damps in was also present in traces. Caffeic acid, ferulic acid, vanillic acid, anisic acid and chlorogenic acid among phenolics, fumaric acid among organic acids were important constituents of air-dried parts of the plant, many of them being traced in the leaf washings, pollen and trichome leachates. But some contradictory studies showed a stimulatory effect of *P. hysterophorus* L. on growth of cereals and legumes at low concentration. Studies also revealed that 1% *Parthenium* ash concentrations enhanced seed germination, plumule and radicle length and biomass production (Tefera, 2002; Singh, 2005; Verma and Rao, 2006). But its growth stimulatory role needs further investigations.

Beneficial effects

Antidiabetic: Aqueous extract of *P. hysterophorus* L. exhibited significant hypoglycemic activity (Table 2). Fasting blood glucose level in alloxan induced diabetic rat reduced considerably

Table 2: Beneficial effects of *Parthenium hysterophorus*

Effects	Features	References
Health benefits		
Antidiabetic	Aqueous extract exhibited significant hypoglycemic activity	Kar *et al*. (1999), Patel *et al*. (2008) and Khan *et al*.(2010)
Antioxidant	Methanolic extracts showed the high antioxidant effect	Ames *et al*. (1993), Ramos *et al*. (2001) and Khan *et al*. (2011)
Antitumor	Consumption of its flower caused alteration in neoplastic markers thereby slowing down the development of tumors	Mukherjee and Chatterjee (1993)
Antimicrobial	Against *S. aureus*, *P. aeruginosa*, *E. coli*, *A. niger*, *C. albicans* and *F. oxysporum* Ethanolic extract exhibited trypanocidal activity	Talakal *et al*. (1995) and Khan *et al*. (2011)
Larvicidal	Root and stem extract toward larvae of *A. aegypti* and leaf extract toward mustard aphid	Sohal *et al*. (2002) and Kumar *et al*. (2011)
Signal transduction	Depolarizing neuromuscular junctional blocker	Vijayalakshmi *et al*. (1999)
Agriculture		
Compost	Higher N, K, P content and considerable content of organic carbon, C/N, the C/P ratio	Apurva *et al*. (2010), Yadav and Garg (2011) and Khaket *et al*. (2012)
Herbicide	Toward *Eragrostis tef, Cynodon dactylon, Cyperus rotundus, Digitaria sanguinalis, Portulaca oleracea, Echinochloa crus-galli, Euphorbia prostrata* and *Xanthium strumariam* etc	Maharjan *et al*. (2007) and Nigatu *et al*. (2010)
Pesticidal effect	Antifeedant action against *Spodoptera litura* Insecticidal activity against *Callosobruchus aculatus* phytotoxic activity against *Cassia tora* nematicidal activity against *Meloidogyne incognita,*	Sohal *et al*. (2002) and Datta and Saxena (2001)
Waste treatment		
Heavy metal and dye removal	Nickel removal and methylene blue dye absorbing efficiency from wastewater	Ajmal *et al*. (2006), Singh *et al*. (2008) and Patel (2011)

($p<0.01$) within 2 h. Identification of its active principle can help in the formulation of a potent allopathic medicine for diabetes. Furthermore, it is interesting to learn that hypoglycemic activity was observed only in alloxan induced diabetic rat.

Alloxan destroys β-cells of the pancreas and induces diabetes due to production of reactive oxygen species. Therefore, unlike the clinically used oral sulphonylurea, this herbal extract does not work by stimulating β-cells for releasing insulin and some other underlying mechanism to delineate blood glucose. So, this may be effective and promising for insulin independent, type II diabetic patients only (Kar *et al*., 1999; Patel *et al*., 2008; Khan *et al*., 2010).

Antioxidant: Free radicals are considered to be causative agent for many diseases. Restriction on the use of synthetic antioxidants is being imposed because of their carcinogenicity (Ames *et al*., 1993). So, natural antioxidants have gained interest of scientists. The methanolic extracts of *P. hysterophorus* showed the high antioxidant effect as compared to *Stevia rebaudiana* (Ramos *et al*., 2001; Khan *et al*., 2011) (Table 2).

Therefore, this plant can be an effective potential source of natural antioxidants. After exploring *Parthenium* for its active antioxidant constituent, a strong natural antioxidant can be made commercially available.

Antitumor: The methanolic extract of *P. hysterophorus's* flower revealed antitumor activity in host mice bearing transplantable lymphocytic leukemia (Table 2). Level of neoplastic markers like glutathione, cytochrome P-450, glutathione transferase and UDP-glucuronyl transferase altered substantial thereby slowing down the development of tumors and increased survival (Mukherjee and Chatterjee, 1993).

Antimicrobial: *Parthenium hysterophorus* exhibited antibacterial and antifungal activity against *S. aureus*, *P. aeruginosa*, *E. coli, A. niger, C. albicans* and *F. oxysporum*, respectively (Table 2). *In vivo* trials revealed that ethanolic extract of *P. hysterophorus* flowers also exhibited trypanocidal activity by significantly reducing ($p<0.01$) mean parasitaemia without any side effect on experimental animal (Talakal *et al*., 1995; Khan *et al*., 2011).

Larvicidal: Studies also demonstrated larvicidal potency of root and stem extract against larvae of *A. aegypti* and their benefits as new group of mosquito larvicides. Active constituent's level of *P. hysterophorus* extract may be responsible for the variability in their potential against *A. aegypti* (Kumar *et al*., 2011) (Table 2). The leaf extract showed the most significant effect in causing a dose dependent decline in both the lifespan and progeny production of adults of the mustard aphid (*Lipaphis erysimi*) (Kalt.) (Sohal *et al*., 2002). Further research is needed to identify these larvicidal components and bring them to effective state.

Other benefits: The studies on rat also confirmed the role of its leaf extract as proven and promising new depolarizing neuromuscular junctional blocker (Vijayalakshmi *et al*., 1999) so, can be used as an alternative of anticholinesterase agent like neostigmine.

Parthenium's compost: The *P. hysterophorus* L. is a rich source of micro and macro-elements like N, P, K, Ca, Mg and chlorophyll and thus preferably suited for composting (Kishor *et al*., 2010; Khan *et al*., 2011). But, its higher phenolic content impedes the early growth, development and dry matter yield of plants. However, combined compost of *Parthenium* and *Eichhornia crassipes* (a water weed, rich in polyphenol oxidases) resulted in significant reduction in phenol, organic carbon contents and C/N, C/P ratios. This revealed that composting of *Parthenium* with *Eichhornia* not only reduced the allelopathic effect of *Parthenium* but also increased its available nutrient content. Further, combined composting of *Parthenium* and *Eichhornia* is a remedy for controlling these weeds and a way to healthy organic farming (Khaket *et al*., 2012).

Vermicompost of *Parthenium*, has also been effectively explored for using its nutrients and overcoming the weed toxicity (Yadav and Garg, 2011). In vermicompost, significant decrease in phenol content, C:N ratio and heavy metals content was observed. Compost prepared in presence of *Harphaphe haydeniana* resulted in higher nutrient and less allelochemicals content. It exerted more beneficial effects on growth and development of *Triticum aestivum* compared to ordinary *Parthenium* compost (Apurva *et al*., 2010). The results revealed a higher increase in N, K, P and considerable decrease in organic carbon, C/N, the C/P ratio in *Parthenium* compost, which can be beneficial for crops (Table 2).

Herbicide: In last two decades, researchers have focused on plant derived compounds as eco-friendly herbicides alternative to herbicides for weed control. *Parthenium hysterophorus* extracts showed significant reduction in weed density and has also shown allelopathic effects toward *Eragrostis tef*, *Cynodon dactylon*, *Cyperus rotundus*, *Digitaria sanguinalis*, *Portulaca oleracea*, *Echinochloa crus-galli*, *Euphorbia prostrata* and *Xanthium strumariam* etc. (Maharjan *et al*., 2007; Nigatu *et al*., 2010) (Table 2).

The sesquiterpene lactone is thought to be responsible for its allelopathic interference with surrounding plants by inhibiting cell division mediated through gibberellin and indole acetic acid (Kishor *et al*., 2010). This observation also gained support by the recent studies that >3%

concentration of *Parthenium* ash reduced germination, plumule, radicle length and biomass production of seeds (Kumar and Kumar, 2010). Keeping in view the decreasing trend of weed germination, density and biomass with the increasing concentration of *Parthenium*, there is strong evidence of *Parthenium* extract to be used as potential herbicide. However, many factors have yet to be studied.

Pesticidal effect: Modified parthenin showed antifeedant action, insecticidal activity, phytotoxic activity and nematicidal activity against sixth-instar larvae of *Spodoptera litura* adults of *Callosobruchus aculatus*, *Cassia tora* and *Meloidogyne incognita,* respectively (Table 2). Among parthenin derivatives saturated lactone, pyrazoline adduct and propenyl derivatives showed significant antifeedant, insecticidal, phytotoxic and nematicidal activities towards the studied species. Insecticidal activity of pyrazoline adduct of parthenin is comparable to *Indica azadirachta* (neem) (Sohal *et al*., 2002; Datta and Saxena, 2001).

Heavy metal and dye removal: Sulphuric acid-treated *Parthenium* showed nickel removal and methylene blue dye absorbing efficiency from wastewater or industrial wastes. Ni removal was maximum at pH 5.0 and achieved within 4 h after the start of every experiment (Table 2). Dye adsorbing ability was also found to be comparable to commercial adsorbents.

The cadmium adsorbing ability of *Parthenium* was also explored, which was maximum at pH 3-4 with recovery of 82% with 0.1 M HCl as effluent (Ajmal *et al*., 2006; Patel, 2011). Activated carbon prepared from *Parthenium* showed cresol (a phenol derivative) adsorbing ability comparable to commercial grade activated carbon (Singh *et al*., 2008; Patel, 2011). As, heavy metals (Ni and Cd), cresols and dyes caused cancer and other diseases in humans so, their treatments or removal from industrial wastes becomes necessary, which make *Parthenium* a better, cheaper and eco-friendly source as an adsorbent.

Controlling *Parthenium*

Use of competitive plants: Under the biological control methods, using plant with allelopathic effect(s) is an significant module for *Parthenium*. Usually, two approaches are followed for *Parthenium's* biocontrol i.e. (1) through maintaining naturally occurring biodiversity and (2) through planting selected plant species in target areas (Wahab, 2005). Botanical survey in India revealed that species such as *Cassia sericea, Cassia auriculata, Cassia tora, Croton bonplandianum, Amaranthus spinosus, Hyptis suaveolens, Sida spinosa, Tephrosia purpurea* and *Mirabilis jalapa* are effective upto a level for control of *Parthenium* in its natural habitats (Kandasamy and Sankaran, 1997; Wahab, 2005; Ayele, 2007).

Parthenium is also suppressed by other plants such as *Sorghum halepense*, *Imperata cylindrica*, *Echinochloa crusgalli*, *Desmostachya bipinnata, Otcantium annulatum, Sorghum halepense* and *Senna obtusifolia*, etc (Bryson, 2003; Anjum and Bajwa, 2005; Ayele, 2007). Similarly, some grass varieties such as *Dichanthium aristatum*, *Bothriochloa insculpta* and *Cenchrus ciliaris* out compete *Parthenium* and among the legumes, *Clitoria ternatea* competed strongly with *Parthenium* (O'Donnell and Adkins, 2005; Ayele, 2007).

Eucalyptus oils from *Eucalyptus globulus* and *Eucalyptus citriodora* also exert harmful effects on *P. hysterophorus*. It caused inhibition of seed germination, reduction in chlorophyll content and cellular respiration of mature plants. It was also accompanied by increased water loss that caused complete wilting of plants (Kohli *et al*., 1998). Recently, herbicidal activity of *W. somnifera* and

Mangifera indica L. on germination and growth of *Parthenium* has been also observed (Javaid *et al*., 2011). Flavonoid like quercetin-3-O-α-glucopyranosyl-(1→2)-β-D-glucopyranoside, exhibited herbicidal activity against *Parthenium* (Javaid *et al*., 2010a). *Parthenium* weed can be managed upto 90-97% with 4 and 5% concentration of *Datura metel* residues, so *Datura metel* can be used as an effective weedicide for *Parthenium* (Javaid *et al*., 2010b).

Biocontrol agents: Biocontrol of *Parthenium hysterophorus* L. using leaf feeding beetle, *Zygogramma bicolorata* was the most cost-effective, environment friendly and ecologically viable alternative management strategy (Strathie and McConnachie, 2013). This caused 96% defoliation that was being followed in India since 1983. Stem-galling moth *Epiblema strenuana* caused 90, 40 and 82% reduction of weed density, plant height and flower production, respectively (McFadyen, 1992; Navie *et al*., 1998; Dhileepan, 2001, 2007; Shabbir *et al*., 2013).

Furthermore, insects like *Listronotus setosipennis* (stem-boring weevil), *Bucculatrix parthenica* (leaf-mining moth) and *Smicronyx lutulentus* (seed-feeding weevil) also showed *Parthenium's* control (Dhileepan, 2001, 2003; Pandey *et al*., 2001; Dhiman and Bhargava, 2010; Shabbir *et al*., 2013). The establishment of the beetle resulted in considerable reduction of *Parthenium* in localized areas. Because, insects mainly feed on leaves of weed which reappear due to their great regenerative potential of this weed, only little success is achieved in this regard. However, seeds and flowers remain unaffected, which are the main source of its dissemination.

Cladosporium sp. (MCPL 461) spore suspension with 3% sucrose showed 70-80% reduction in seed germination compared to *Lantana camera*, *Chromolaena odorata* (Kumar *et al*., 2009). Cultural filtrates of different concentrations of *A. alternata, D. rostrata* and *Cladosporium* sp. showed 70-90, 27-50 and 13-73% reduction in *Parthenium* seed germination, respectively. Among other fungal species, cultural filtrates of *Fusarium oxysporum, Fusarium solani, Drechslera australiensis* and *Drechslera hawaii ensis* also showed considerable reduction in root and shoot length of *Parthenium* seedlings (Javaid and Adrees, 2009; Saxena and Kumar, 2010).

Several putative fungal isolates were isolated from seed and other plant parts of *Parthenium* plants but most of them were found to have an insignificant potential for biological control of *Parthenium* except *Puccinia abrupta* var. Partheniicola fababean phyllody (PBP) phytoplasma group, which causes rust and phyllody disease, respectively. *Parthenium* seed production was reduced by 42 and 85% due to rust and phyllody, respectively. Insect vectors that transmit phyllody and rust diseases of *Parthenium* showed significant potential for classical biological control of *Parthenium* after confirming its host range for phyllody disease to the related economic plants (Wood and Scholler, 2002; Taye *et al*., 2002; Dhileepan, 2007). Recently, Kaur and Aggarwal (2015) observed that *Trichoconiella padwickii* caused a premature defoliation of *Parthenium* leaves which may be a potent regulator for this weed.

Use of synthetic herbicides: Among synthetic weedicides, norflurazon (100%) and clomazone (100%) showed complete removal of *Parthenium* followed by fluometuron (96%), metribuzin (90%), diuron (87%), flumioxazin (84%), chlorimuron (77%) and quinclorac (67%) after six weeks of treatment under greenhouse. All other herbicides controlled less than 58% of this weed. *Parthenium* also showed sensitivity toward pigment and photosynthetic inhibitors. Among weedicides, use of glyphosate, glufosinate, chlorimuron and trifloxysulfuron at rosette *Parthenium* provided greater than 93% control but halosulfuron, bromoxynil, MSMA, 2,4-D and flumioxazin controlled 58-90% of *Parthenium* after 3 weeks of treatment. *Parthenium* control with all other post herbicides was less than 38%. At bolted stage, weedicide such as glyphosate, glufosinate and trifloxysulfuron controlled 86-95% *P. hysterophorus* and 61-70% with chlorimuron, halosulfuron and 2,4-D, after 3 weeks of treatment. So, post herbicides efficacy was better on rosette stage as compare to bolted stage of weed. Furthermore, alachlor, atrazine, chlorimuron, flumioxazin, fluometuron, imazaquin, norflurazon, quinclorac and simazine also showed significant herbicidal activity (Muniyappa and Krishnamurthy, 1976; Muniyappa *et al*., 1980; Adkins *et al*., 2005; Grichar, 2006; Reddy *et al*., 2007; Tadesse *et al*., 2010).

Amino acid synthesis inhibitors were also found to be more potent than herbicides with other modes of action. Thus, norflurazon, clomazone, fluometuron, flumioxazin, halosulfuron, chlorimuron and trifloxysulfuron may be used as effective controlling agent for *Parthenium* (Reddy *et al*., 2007). Younger, nonflowering plants are more susceptible to post emergence herbicides. Inspite of all control trials, epidemic spread, strong reproductive and regenerative potential make control of *Parthenium* quite difficult.

CONCLUSION

Parthenium hysterophorus L. is a toxic weed for both grazing animals and humans coming into its contact either directly or indirectly. But its aqueous extract showed a hypoglycemic effect on alloxan induced diabetic rat. Further studies are needed to elucidate active principle and the real mode of the action of this herbal extract at the molecular levels in diabetes patients. Nutritious contents offer it as a potential compost but further extensive studies are needed to explore it as a compost and natural pesticide for different crops. Initially, it was thought to be beneficial pesticide because of its allelopathic effects but high concentration become toxic for cereal crops. Its antioxidant activity makes it helpful for a wide range of disorders, including neurodegenerative disorders, cardiovascular disease, cancer and aging. There is a need to develop a cost-effective and simple method to remove harmful allelopathic chemicals for exploting *Parthenium* in useful manner.

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