



REVIEW ARTICLE

***Parthenium hysterophorus* a Threat or Beneficial Weed and Management: A Review**Indranil Singh¹ and Shuchi Kaushik^{2*}¹Independent Researcher²State Forensic Sciences Laboratory, Madhya Pradesh, India.

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ABSTRACT

Parthenium hysterophorus known for its proliferative capacity has run wild through many countries over the globe. It has significant impact in America, India, Australia and Africa. It has potential to cause a huge economical loss to country in the form of crop damage, influencing health of humans as well as of livestock. Today it is considered as one of the seven most noxious weed in the world. It is an annual herb that has been native to northern Mexico as well as U.S.A. It has been known for producing thousands of rosettes responsible for toxicity and its rapid spreading over a region. There has been huge loss in crop yield due to either direct competition or due to allelopathy. There are various methods to tackle its uncontrolled growth such as burning, spraying herbicides, biological control in the form of introducing various insects like *Zygogramma bicolorata*, *Epiblema strenuana* etc. In last few decades lot of beneficial prospects have been developed with the involvement of *Parthenium hysterophorus*. It has been used in traditional medicine to treat conditions like inflammation, pain, fever, and diseases like malaria, dysentery etc. It can be used to produce biogas, enzymes and could also take upon heavy metal pollution and acts as bioremediation agent. It can also be used in dye removal and also be used in removal of various menace causing aquatic weeds. It has been proved to be useful in order to maintain moisture of field and could potentially be used as organic manure. It is proved to be better than NPK synthetic fertilizers, provided optimum conditions have been met. The aim of this review article is to explore various dimensions of *Parthenium* existence and how its uncontrolled growth could be tackled.

Keywords: Allelopathy, biological control, traditional medicines, bioremediation, organic manure





INTRODUCTION

Parthenium hysterophorus also known as carrot grass, white top, congress grass or feverfew belongs to family Asteraceae. At some places it is also known as Santa-Maria or Peterson's curse, 'altamisa' and "Scourge of India". It can survive throughout the year and these herbaceous weeds are obnoxious in nature. There are hardly any efficient benefits of these ephemeral herbs which have been entangled till now. They are prolific weeds known for their vivacious development along with their high fertility rate particularly in hotter atmospheres. These are endemic to America while being local to north-east Mexico. Its expansion has been related to its capability of forming numerous small capitula each with potential to form at least around 5 seeds at maturity. It produces approximately 10,000 to 14,000 seeds in one lifespan which could be dispersed through various mechanisms. Human has been struggling with its rapid spread which has the potential of completely changing the habitat [1]. *Parthenium hysterophorus* can tolerate the extreme of conditions like those in drought scenario or soil condition varying from sandy to wet soils and can complete three generations in a year of time provided it has the favorable growth conditions [2]. It can germinate in wide range of temperature ranging from 10°C to 25°C [3] and requires around 500mm of rainfall in summer season [4]. Last few decades have seen *Parthenium hysterophorus* been spreading throughout the world from India, Africa, and pacific island and especially to Australia [5]. While in India, its emergence has been restricted to about 2000m above the sea level, but cases have been identified where it has been seen to move upward due to human interference and changing climate [6-7]. It has been reported that *Parthenium* possess non-Kranz anatomy with C₃ at the top of leaves and C₄ at the bottom of leaves which follows the Kranz leaf anatomy [8]. Today it is been counted as one of the annihilating and hazardous weeds. It could be found in wide ranges of scenario such as railway tracks, abandoned land, roads, gardens, around buildings etc. which have been favorable for the growth of this weed owing to fact that there is lack of interspecies competition in these areas [9].

Introduction of *Parthenium hysterophorus* in Pune, India was totally a matter of accident, as it came along with PL 480 wheat as a contaminant which was imported from USA in year 1950s. It was carried under Public law 480, which was passed in order to help the country dealing with malnutrition along with insufficient wheat production. Since then, it has spread throughout the country attracting a lot of attention as its growth leads to havoc and destruction of normal flora. It has been found to reduce around 40% of yield in a planted land while itself been able to survive in nutrient deficient conditions [2,10,11]. Further harmful effects on crops growth and yield where *Parthenium hysterophorus* has been growing simultaneously with the crop has been studied by various authors [5,12-13, 96]. It has been estimated that roughly 2 million hectares of land has been under the hazardous influence of *Parthenium hysterophorus* [14]. Another possible mechanism through which *Parthenium hysterophorus* infects and causes shift in natural habitat is either its invasive capacity or its allelopathic effects on plant. It achieves allelopathy through group of allelochemicals. It is the result of parthenin, a sesquiterpene lactone or because of phenolics [15-17]. It acts by undergoing mechanisms like leaching, decaying of fallen parts either by biotic or abiotic means or by going through root exudation [18]. *Parthenium hysterophorus* has many negative impacts on human health when exposed for longer duration. In a study it has been found that it could result into Asthma, respiratory tract infections like bronchitis, along with hay fever, skin lesion and dermatitis [19]. It has potential to greatly affect milk production and meat of animal [20]. The antimicrobial activity of plant is owned to the amount and quantity of its Phyto-constituents. The anti-microbial study of leaf of congress grass has shown that its methanol and acetone extract has potential to act against microorganisms [21].

Growth and Reproduction of *Parthenium hysterophorus*

Parthenium is known for its colonization in wide range of conditions from heavy clays to sandy soil and however it has been known for its better growth in clay soil. It is a highly competitive plant known for its colonizing strength. It can colonize and adapt to wide number of situations from overgrazed pasture to cultivated land, roadside,



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stockyards etc. It could use varieties of means in its spread from one place to another like animals, water, humans, movement of farm products etc. *Parthenium* growth, reproduction and photosynthesis abilities have been highly suppressed under low temperature in winters than in summer. This is due to constrained emergence of seed along with seed to flower ratio and restricted vegetative growth. It was found that below 7°C, rate of photosynthesis highly reduces. Further consideration of CO₂ has resulted into measurable increase in the rate of photosynthesis as well as efficiency in water utilization [6].

***Parthenium* and its Allelopathic Potential**

Allelopathy is considered to be a reason behind reduction in crop along with pasture yield, change in habitat, human health problems and being toxic to nature, livestock etc. These allelochemicals are also the reason behind its ability to dominate over other species and establishment in a new habitat. It has been proven fact that aerial parts of *Parthenium* and weed roots do possess certain chemicals that when extracted with either water or alcohol could lead to reduction in growth and influences its germination. Belgeri and Adkins, 2015 in their work found that response to *Parthenium* seedling was more species specific. It has greater impact over reduction in growth of root as compared to that of shoot. They also found that introduced grasses like Rhodes grass, buffel grass and siratro were least affected with 0%, 8%, and 9% inhibition respectively, as compared to the native grasses like curly windmill grass and cotton panic grass that showed around 54% to 59% of inhibition [22]. Further elucidation has been done to identify its chemical constituents and properties. Sesquiterpene lactone is considered as toxin and has been found to be present in almost all parts of *Parthenium hysterophorus* including pollen grains and trichome. Deeper investigation has resulted into discovery of glycoside parthenin which is bitter and a major sesquiterpene lactone [23]. Along with this, there are other chemicals like sitosterol, caffeic acid, 3,7-dimethylether, quercelagetin, ferulic acid, vanillic acid, p-coumaric, P-hydroxy benzoin and vanillic acid, 6-hydroxyl kaempferol 3-O-arabinoglucoside and some other unidentified alcohols, which are the reasons behind the proliferating nature of *Parthenium* [24]. *Parthenium hysterophorus* isolated from varying geographical positions has revealed different major constituents like dihydroisoparthenin, hysterophorin, hymein, tetraneurin and coronopilin [25]. Another group of workers have isolated a novel compound i.e. allergen named hydroxyproline-rich glycoprotein [27]. Das et al. (2007) in their work mentioned four acetylated pseudoguaianolides [26] Venkataiah et al. (2003) in their work reported the discovery of seco-pseudoguaianolide named charminarone, a novel sesquiterpenoid [28].

Hazardous Impact of *Parthenium* Weed

Parthenium a noxious weed is proved to be a significant danger not only for agriculture but has been a causal reason of various diseases affecting human and livestock. It is considered to be invasive alien species in Asia, Africa and Australia as it has been introduced accidentally and lately these plants have developed and established their self-reproducing states [29-30].

***Parthenium* and Agriculture Productivity**

Over the period of time *Parthenium* has emerged as the worrisome issue for farmers. In depth examination of *Parthenium* and its parts in various organic solvents has led us to conclusion that it has potential of severely affecting various parameters of growth. Parameters involving but not limited to it are rate of germination, amount of shoot and root growth, amount of yield and amount of seedling production [31]. *Parthenium hysterophorus* leaf extract in aqueous medium has been found to potentially affecting three major cereal crops grown in and around India i.e. *Oryza sativa*, *Zea mays* and *Triticum aestivum*. In the same work, three other crucifer vegetables along with two from Asteraceae family were also found to be highly affected by *Parthenium hysterophorus* [32]. Khan et al. (2012) has further studied impact of *Parthenium hysterophorus* on *Triticum aestivum* and reported that it is most susceptible to *Parthenium* noxious effect. Another work on *Zea mays* has suggested that inhibition is done by *Parthenium hysterophorus* by inhibiting either seed germination or seedling vigor [34-35]. Fruit development as in case of plants like brinjal, tomato and chili etc. has been impacted by allelopathy of *Parthenium* [36]. 40% loss in production of rice



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and almost around 90% of loss in case of pasture has been reported along with devastating effect on plants like mustard, linseed, and chickpea [37]. In Ethiopia, it has been reported to cause around 40% to 97% of losses of sorghum grain when *Parthenium* is left uncontrolled there [3]. Accumulated *Parthenium* pollen on floral parts of maize plant has potential to cause reduction in grain filling by 50%. Another work suggested that in case *Parthenium* is being burnt as a method of eradication could lead to ash deposition which is further found to be responsible for affecting rate of germination along with reduction in plumule and radical length in case of *Phaseolus mungo* [38]. It too has adverse effect over nodulation in legume plants because its presence has found to have negative impact on biological nitrogen fixation causing bacteria [39]. The weed too has potential to act as alternate host for the insects which are pest for various other plants. Few prominent examples are insect mealy bug, scarab beetle, etc. [3]. Numerous crop viruses along with bacterial wilt pathogen have been recovered from various parts of the plant throughout the world. It is believed to cause infection either in pod formation stage or in the pre-flowering time [40]. In a study, it has been estimated that cost could be double by the time crop take its final form and has been further localized into certain restricted area owing to fact that it has been contaminated with *Parthenium* [41]. Both burnt and unburnt extracts of *Parthenium* have been kept on test for check of its potential in regard to the noxious effect over crop. It has been found that burnt has more potential effect over crop than the unburnt *Parthenium* although both have been found to be toxic against the crop. The reason why burnt has been more toxic is due to its highly alkaline nature and presence of phenolic compounds [42].

***Parthenium* and Biodiversity**

Parthenium is harmful towards the biodiversity of any region, which is being accounted by its allelopathic and invasive attributes that renders *Parthenium* its potential to run wild in ecosystem and to create havoc. It leaves very little or no vegetation in infested territory [30]. Its mere presence in a region could lead to influencing scenario over the diversity and further to their displacement along with imbalance between various forces of nature [43]. *Parthenium* along with another weed known as rubber vine, are seen today as greatest threats to biodiversity as is the case in bioregion of Einasleigh uplands [44]. The most adversely affected regions where significant to complete change in habitat has been seen are, grasslands of Australia, flood prone regions, banks of river and the open woodland [45]. Further investigation in varied regions of world has been done to investigate its effect but has yielded the same conclusion [46-48]. In another work, it has been argued that its secondary metabolite possession has been responsible for the status of invasive alien species [30].

***Parthenium* Influence over Human and Livestock**

Over the period of time, it is appeared that *Parthenium* continuous exposure to people could potentially lead to disease like condition. People living in close proximity to *Parthenium* may also show allergic immune response. Almost all parts of the plant, from root to pollen material, have the potential to induce or to make person prone to *Parthenium* related diseases [50-51]. Conversely, a man who has hypersensitivity may likewise have an unfavorably susceptible response to *Parthenium* despite the fact that they may not be so sensitive to the plant itself. There are many diseases related to *Parthenium* which includes hay fever, allergic bronchitis, contact dermatitis, Phyto photodermatitis etc. [23,51]. Intake of *Parthenium* pollen grains through breathing can cause unfavorable rhinitis that can convert into more severe respiratory disorders such as bronchitis or asthma. *Parthenium* escalated virulence factor is the result of cyclopentene that could lead to intensified result in the form of alteration in chromosome, inhibition of functionally important enzymes or uncoupled phosphorylation. Wiesner et al. (2007) in his work reported that *Parthenium* has the potential to cause skin irritations, cracks in skin, stomach aches, and hand ball pustules in addition to above mentioned diseases. An observation-cum-evaluation in Queensland demonstrated that around 10% of people working in swarmed *Parthenium* zones had showed noticeable hypersensitive to *Parthenium* [1, 52]. About 10 to 20% of people found to be vulnerable to hypersensitivity from *Parthenium* when exposed or remained under its influence for 1-10 years [53]. Studies with *Parthenium hysterophorus* on *Salmonella* and bone marrow of mouse for its mutagenic potential were carried out but the results proved out to be negative for genotoxic potential [54]. In another work, it has been reported that there has been shift of airborne dermatitis towards a pattern that could be mixed to chronic in



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nature [55]. Further Siramarao et al. (1993) found the positive co-relation between the prick test conducted on skin and the presence of *mAb-2* [56]. Gunaseelan (1987) was among the first few researchers to report that *Parthenium* cause toxicity to plants too. Animals that have been feeding on *Parthenium hysterophorus* as well as *Parthenium* pollen infected crop, were found to be positive for Alopecia, diarrhea, reduction in skin pigmentation and dermatitis [49]. Cattle like sheep, buffalo etc. has been found to be with inhibited liver dehydrogenase enzyme along with some degenerative changes in two of the major organs mainly kidney and liver [57]. Further work on *Parthenium* led to the conclusion that consumption of *Parthenium* could even result in deterioration of meat along with milk production [45]. Yadav et al. (2010) has studied correlation between *Parthenium* and WBC count and found a significant reduction in the count in organisms post treated with parthenium. *Parthenium* is found to be a potential cause behind various other diseases like dermatitis, lesion on skin, mouth ulcer and hyper salivation like condition, irritation in eyes etc. In few conditions, it can be very lethal for animal with potential to harm and rupture tissues and organs [58].

Management and Elimination of *P. hysterophorus*

Parthenium hysterophorus has been known for its harmful effects on environment, agriculture, livestock and human. All the very reason it has become very important to control its proliferation or to evolve certain mechanism that could result into its eradication. Today there has been several methods in play to get hold of it like manual and mechanical removal, use of biological or chemical procedure, and preventing seed from spreading [59-60]. However, it has become a matter of concern owing to the fact that it could lead to epidemic proliferation and has a strong reproductive potential [61]. Burning is not something to be suggested as a control measure in case of *Parthenium hysterophorus*. The current observation has revealed that burning *Parthenium* could lead to strong infestation by decreasing pasture competition and favoring *Parthenium* growth. *Parthenium* prevention may be much cheaper as compared to eradication once it has developed to full fledged condition. Hence, many countries prefer to regulate as well as supervise before importing any field yield from *Parthenium* infected region [33]. Spraying weedicides earlier even before they start having their seed could be another method to deal with these noxious weeds, further it should be kept under observation for next two years in case of reemergence of weed. While in the non-crop areas and further areas along railway track or in abandoned land, spraying of 15-20% of salt solution could be effective to get rid of it. And in case of cropped land, one can also spray 1% glyphosate solution in *Parthenium* infested field [62]. Recently Shabbir et al. (2020) showed biological agent when combined with competitive plant like *C. ternatea* and *Aster blaeuana* could result into reduction of dry biomass from shoots and also reduction in seed banks with simultaneous decrease into the seedling recruitment in case of upcoming generation [63]. The drawback behind the use of herbicide is pollution and imbalance in ecosystem. Today, biological control has emerged as less expensive, safe for ecosystem and viable in context to environment. Biological control is found to reduce weed population along with enhancement in fodder plant production [64]. Few of notable biological control has been carried out by *Listronotus setosipennis* a stem-boring weevil, *Zygogramma bicolorata* beetle that feed over leaf and *Epiblema strenuana* that is stem-galling moth [95]. These have been successfully employed in order to deal with *Parthenium* havoc [65]. *Psidium guajava* and *Artemisia absinthium* has also shown to significantly impact *Parthenium* germination, development of seedling, and photosynthetic pigment content [66]. Despite of so much of benefits, biological control too has some drawbacks like it consumes very minute amount of foliage and hence insignificant in fast and effective action. It is further worsened by the fact that these weeds do possess higher regenerative potential [67].

Economical Importance of *P. hysterophorus***Health related benefits**

P. hysterophorus has the potential to be used as a medicine. From quiet a long time it has been used as a medicine to treat various diseases like neurological disorders, inflammation, fever, malaria, gynecological ailments, herpes, diarrhea, emmenagogue, urinary tract infections etc. [68]. In another work it has been reported to act as pharmacologically active substance with capability to treat muscular rheumatism [23]. It has been found effective



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against hepatic amoebiasis as well as reported to have possession of anti-cancer properties [23,28,69] were among the first few to report positive result in terms of tumor size reduction and also in cell life span when analyzed *in-vivo* as well as *in-vitro* [69]. Flower when leached out in methanol showed anti-tumor activities while parthenin showed some cytotoxic attribute against T-cell, and cancer cell line [26]. In yet another work it has been found useful to treat hypoglycemia condition with *Parthenium* in diabetic induced rats [70].

Crop production enhancement

Allelopathy could be exploited to be used as a potential substitution to chemical products like fungicides, insecticides, and growth regulators. It could enhance crop yield because of its attributes like disease resistance and at the same time eco-friendly in nature, which could prove very useful in future. It could most probably replace the chemical that is being used as pesticides because of its ovicidal and anti-fleedant properties [71]. In another work, Kishore et al. (2010) reported that *Parthenium* could probably enhance moisture level more efficiently than other attributes of soil like NPK level. It has been reported that it could be used as organic manure too [72,73]. It has been field tested as the potential prospective of green manure against maize, with utmost benefit achieved during administration of 3% parthenin derived green manure treatment. Further elaborating his work, he reported that parthenin could lead to around 42-253% increase in production as compared to only 96% increase when NPK has been administered. Apurva et al. (2010) reported the formation of multi composting to enhance the production without incurring any harmful effects and it has proved to be more beneficial than just parthenin composite [74].

Hussain et al. (2017) in his work tried to form vermicompost of parthenin and to further use it as organic fertilizer on *Abelmoschus esculentus*. As a result, he found that vermicomposting has helped to increase growth rate at same rate of germination along with increase in fruit yield and nutrition enhancement. It has further proved to be free of toxicity and raised the prospect of using it as a boon in future [75].

Bioremediation through *Parthenium*

Heavy metal pollution has emerged as one of devastating cause for degradation of environment. Anthropogenic activities like industries of storage batteries, refineries, casting of different metals like zinc etc. and electroplating adds a huge chunk of heavy metal into environment. At high concentration these can turn out to be carcinogenic and develop ability to induce tumor in normal organisms. This demands for development of a cost-effective way to deal with heavy metal pollution. Bioremediation and Biocontrol are one of the sought approaches to deal with bioremediation and comes into many shapes [77, 78]. A study carried out reported that *P. hysterophorus* can sequester nickel from solution [76]. In the same research it has been argued that addition of Sulphuric acid to treat *Parthenium* biomass could turn out to be an effective, cheap and easy to procure heavy metal remover from aqueous solution. Another research focused toward absorption of Cd (II) from wastewater. Cd (II) has been extensively used in metallurgical, manufacturing of plastic and in the electroplating industry. It is reported to cause various lethal diseases at lower as well as higher accumulation, such as increase in blood pressure, deformity in brain, disorder of urinary tract and the destruction of RBCs etc. Atomic Absorption Spectroscopy (AAS) has verified result further showing the absorption at wide range of concentration with pH ranging from 3-4 with efficiency equivalent to 99.7%. In yet another work, *Parthenium* activated carbon is proved to be over edge as compare to that of activated carbon in availability as well as cost and regeneration [42]. *Parthenium* assisted with ZnO-NP has been shown recently as a potent phytoremediation agent for Pb with 98.2% of accumulation; 86% in case of Ni; and zinc accumulation was 91.4% when they treat fly ash soil containing respective metals [79].

Additional benefits of *Parthenium*

Parthenium hysterophorus has been studied for its ability to produce enzyme like xylanase [14]. Dried leaf powder when sprayed over weeds like water lettuce, *Salvinia* etc. out compete aquatic organisms leading to their death. It has been found that these weeds could get infected with wilting and desiccation in the parts above water when sprayed with *Parthenium* [80,81]. Biomass of weeds has been observed to be highly reduced when *Parthenium* has



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been applied in varying concentration before and after emergence [81,82]. *Parthenium* has been found to be very effective against removal of various kinds of dyes, dissolved heavy metals, and other compounds like phenolics [83]. Nanotechnology has emerged as a wonderful option to tackle various issues in day to day life. It has been highly beneficial for the industry involving imaging, mechanical, electronic, drug delivery, and molecular diagnosis [84,85]. Nanoparticles (NPs) can be broadly classified into organic and inorganic type. NPs can be synthesized from various processes like sol-gel method, thermolysis, hydrolysis etc. [86]. But chemical and physical methods have their own issues leading to the biological synthesis of NPs from Bacteria, algae, fungi and plants extract [87,88]. Recently there has been increase in interest of researcher toward synthesis of NPs from *Parthenium hysterophorus* like TiO₂, AgNPs, and Zinc oxide nanoparticles [89-91]. These nanoparticles were further shown to be useful as antifungal agents, antibacterial, eco-friendly, and in controlling vector born disease [89-91]. Further *Parthenium* has shown magnificent result in the production of efficient biogas when added along with manure [49]. Nargotra et al., (2019) has reported bioethanol production from the *Parthenium hysterophorus* on pretreatment with surfactant that has been assisted with ionic liquid. *Parthenium* has also been studies to produce biogas with the help of anaerobic digestion [92-94].

CONCLUSION

Parthenium is the most common weed found to inhabit almost all over the world. Despite of its harmful effects on the flora and fauna of its habitat, the whole plant or its parts may be used for extracting some useful components from it, which may further be utilized as agricultural, industrial, and pharmaceutical products.

Conflict of Interests

There are no conflicts of interest.

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