

## A Short Review on Threats, Benefits and Control of *Parthenium hysterophorus*- A Hazardous Weed

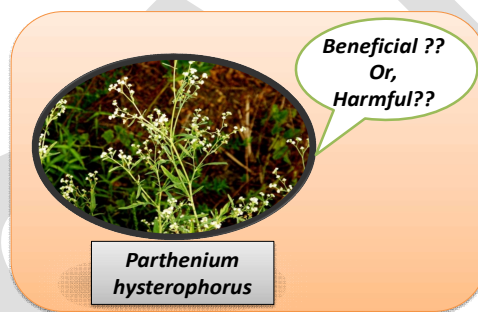
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### Abstract

*Parthenium hysterophorus* L., a globally distributed weed, belongs to the class of world's worst weeds. It can affect human and domestic animals health, cultivation, environment and natural biodiversity with remarkable financial implications. Several managing methods such as chemical, mechanical and biological control have been used to curtail the damages produced by this weed. This review article sheds lights on the usefulness of *Parthenium* and provides essential information on the morphology, replica, ecological impacts, benefits and possible control strategies.



**Keywords:** Carrot grass, Allelochemicals, toxicity, Benefits, Management

### Introduction

*Parthenium* weed, *Parthenium hysterophorus* L. is usually known as American feverfew, white top, whitehead and due to the similarities of its leaves with that of carrot it is also known as carrot grass. This weed is short-term recurrent herbaceous plant<sup>1</sup> and wherever it grows, damages the natural ecosystems of that area.<sup>2</sup> It causes severe allergic effects in humans as well as domestic animals<sup>3,4</sup> and causes substantial difficulty in drylands,<sup>5</sup> crops and forestation.<sup>6,7</sup>

*Parthenium hysterophorus* was very well known to the area surrounding of Central, Southern North and Central South America along with Gulf of Mexico and West Indies.<sup>8,9</sup> But it has the capability to blowout very fast and presently we can find it around the whole world<sup>10</sup> together with mainland and island because it has certain properties like insensitivity towards heat or sunlight and easily adopt the different weather conditions which permit it to bloom from sea level to the Central Himalaya in India.<sup>11</sup> As this weed belongs to the world's seven most disturbing and detrimental weeds, every year it causes immense natural and agricultural damages. It is believed that this unfamiliar weed has been familiarised in India as impurities in PL 480 wheat imported from the USA in the 1950s.<sup>12</sup> *Parthenium hysterophorus* can be found all across India and creating risk in many states. Mainly those states having large cropping or non-cropping land and

grazing land, the problem is serious.<sup>13</sup> Because of its invasiveness, faster spreading, effect upon public and livestock health, financial and ecological impacts it is known as one of the nastiest weeds.<sup>3-7</sup> Presently India is one among the most infected countries by *Parthenium* weed.

### 1. Botanical and Chemical analysis of *Parthenium*

*Parthenium hysterophorus* is extremely branched, vertically standing herbaceous plant that has yearly life cycle and forms a rosette habitat (Figure-1) in the first stage. At the early stage, basal rosette of *Parthenium* is consist of brilliant green and thinly lobed leaves that spans around 8–20 cm in length and 4–8 cm in breadth. In this primary stage it can grow up to a maximum of 2.5 m in length at certain condition.<sup>14,15</sup> Different types of fluffy hair or trichomes are found in the stem and leaves of *Parthenium*, few of which have been documented for their taxonomic implication.<sup>16</sup> The heads of the flowers are terminal and little bit hairy, having several small white capitula-shaped florets. Generally, each top has five fruitful ray florets, although infrequently six or eight. So many branches which grows in different conditions can make flattened seeds of black color about 2 mm in size.



Figure-1: The rosette stage of *Parthenium*

Beside physical properties, the chemical composition of different part of the weed has been studied in detail to determine the chemical properties of the naturally occurring organic molecules. Chemical analysis of the different part of *Parthenium* (including, stem, leaves, pollen, trichomes etc.) revealed that all its parts contains chemicals that are classified as toxin.<sup>17</sup> The toxic chemicals which are present in *P. Hysterophorus* listed in table-1 and figure-2 shows some sesquiterpene lactones isolated from this weed.

Table 1: Chemical constitution of *Parthenium*<sup>18</sup>

Plant parts	Major constituents	Chemicals class	References
stem, leaves and pollen	parthenin, <i>p</i> -coumeric acid, caffeic acid,	Sesquiterpene lactones	Kanchan and Jayachandra <sup>19</sup>
root and leaves	ferulic acid, anic acid, fumaric acid, vanillic acid,	Phenolic acids	Valliappan and Towers <sup>20</sup>
stem, flowers and trichomes	Coronopilin	Sesquiterpene lactones	Picman <i>et al.</i> <sup>21</sup>
flowers	ambrosionalides, 2B-hydroxycoronopilin, 1,3-hydroyparthenin	Minor sesquiterpenes	Sethi <i>et al.</i> <sup>22</sup>
stem and leaves	pseudoguananolides	Sesquiterpene lactones	Fuente <i>et al.</i> <sup>23</sup>
Stem	Hystrin	Sesquiterpene lactones	Vivaret <i>et al.</i> <sup>24</sup>
all plant parts	charmararone	Seco-pseudoguananolides	Venkataiahe <i>t al.</i> <sup>25</sup>
aerial parts	aglycone flavanols	Flavonoids	Shen <i>et al.</i> <sup>26</sup>
flower	hysterones A to D	Pseudoguananolides	Ramesh <i>et al.</i> <sup>27</sup>
flower	acetylated pseudoguananolides	Sesquiterpene lactones	Biswanath <i>et al.</i> <sup>28</sup>

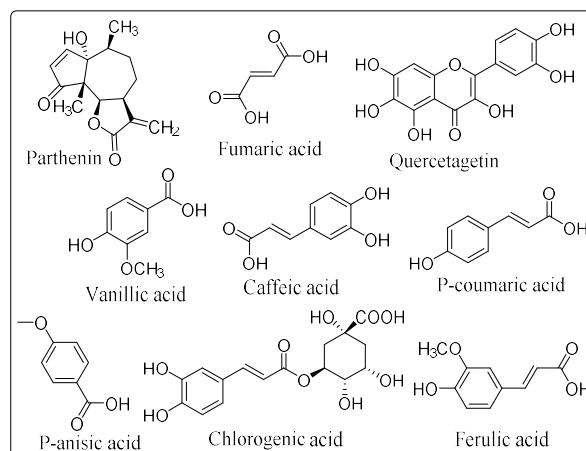


Figure 2: Some sesquiterpene lactones isolated from *P. hysterothorus*<sup>17</sup>

### 2. Reason of faster growth

*Parthenium hysterothorus* hold an amazing competence to vigorously grow and spread in variety of environmental condition. Due to its short life cycle, of about 3 to 4 months, it can quickly grow in number and spread quickly.<sup>29</sup> This can take place round the year which allow it to spread dynamically and as a result it can form a bulky number of seeds. These seeds endlessly boost the size of its soil seed bank.<sup>30</sup> In the soil seed bank its seeds can survive for around 4-6 years. It can also be circulated via a variety of methods such as watercurrent, animals, vehicles, machinery, livestock and the other seeds of crops.<sup>31</sup> Extraordinary productivity, high growth rate, allelopathic effects are some capacities of *Parthenium hysterothorus* which supports it to spread speedily caused in invasion of *Parthenium* all over.



Figure 3: Life cycle of *Parthenium hysterothorus*<sup>32</sup>

### 3. Detrimental Properties of *Parthenium*

*Parthenium* weed has serious impact on each and every component of the ecosystem. Some of these are discussed below:

## (a) Human Beings

There are number of chemical elements found in *Parthenium* are very damaging to humans as well as livestock; examples are anisic acid, chlorogenic acid, caffeic acid, p-anisic acid, and benzoic acids etc.<sup>33</sup> Major health problem caused by different parts of *Parthenium* weed are dermatitis, hay fever, asthma, and bronchitis. Chances of skin diseases, allergies related to *Parthenium*, malarial infection-related fever increases due to hand picking of *Parthenium* directly from the field. Extensive exposure to this weed can also cause skin allergies or infections, fever, eczema, dark spots, burning, swelling around the eyes,<sup>34</sup> diarrhea, extreme popular erythematous eruptions, and shortness of breath.<sup>17</sup> Long term exposure (3 to 5 years) to this weed can cause serious respiratory syndromes such as asthma and allergic bronchitis.<sup>35</sup>

## (b) Livestock

*Parthenium* weed is noxious for livestock. Poisoning may result when cattle directly guzzle or come into interaction with *Parthenium* on consistent basis.<sup>36</sup> Alopecia, dermatitis, loss of skin pigmentation and diarrhea are some common problems associated with animals feeding on this plant. Furthermore, meat and milk of cow, buffalo and sheep feeding on the weed becomes unpalatable due to its undesirable flavor.<sup>37</sup> In buffalo and sheep the function of kidney and liver was reported to be deteriorated after prolonged consumption of this weed.<sup>38</sup> Excessive consumptions of this weed by cattle can be life threatening.

## (c) Biodiversity

Due to lack of natural enemies and its short life cycle, *Parthenium* weed has the power to disrupt the regular ecosystem via its invasive growth. As it is a violent colonizer, it cuts the growth of meadow and reduces forage production. Local flora and fauna are also in danger, which reduces the biodiversity of an area.<sup>39</sup> Suppression of native vegetation can also be found due to the speedy germination and faster growth of this weed in almost all type of weather conditions. Growth inhibitor allelochemicals like lactones and phenols released from the plant into the soil either as root exudates or by leaching and decay of residues suppress the progress and production of native plants.

## (d) Crop production and Soil Microflora

In India *Parthenium hysterophorus* weed has invested in a massive area.<sup>40</sup> Singh et al. has reported<sup>41</sup> the allelopathic assets of burnt (BR) and unburnt (UR) residues of *P. hysterophorus* and the extract prepared from both of these residues were toxic. Due to high alkaline nature BR extract shows more toxicity. This plant contains allelochemicals viz. parthenin, hysterin, hymenin, ambrosin, caffeic acid, coronopilin and p-coumaric acid which have serious allelopathic effects on various crops as well as on human being.<sup>42</sup> *Parthenium* can potentially disrupt the N<sub>2</sub> fixation pathway in legumes with bacteria like *Rhizobium*, *Azospirillum*, *Azotobacter* and Actinomycetes.<sup>43</sup> Extracts from pollen and other plant parts of *Parthenium* also prevents seed germination and fruits growth in crops like chili, tomato, brinjal, etc.<sup>44</sup> It behaves as an substitute host for the insect scarab beetle, mealy bug and it can also act as an appropriate host for tobacco streak virus, tomato leaf curl

virus and aster yellows phytoplasmas.<sup>44,45</sup> Aqueous extract of *Parthenium* has been reported to have adverse effects on the growth of *Rhizobium*, *Nitrosomonas* and *Azotobacter*.<sup>43</sup> Symbiosis of *Rhizobium*-legume is affected due to the reduction of Leg haemoglobin content of root tubercle by this weed. Allelochemicals leachates from root and leaf have fungicidal property which can inhibit nitrate production and also prevent the growth of mycorrhizae and algae connected to crop plants.<sup>46</sup> Allelochemicals extracts from *Parthenium*, either released via leaching or decomposition, affect the physic-chemical health of the soil and thereby adversely impact progress of other plant species. In India *Parthenium* can cause ~40% loss in legume crops production.<sup>47</sup>

## 4. Beneficial aspects of *P. hysterophorus*

Though *P. hysterophorus* is a detestable herb, but if used in correct way, it can also prove to be an important resource.

### a) Medicinal benefits

There are a significant number of health benefits of *Parthenium* which are summarize in table-2.

**Table 2: Medicinal benefits of *P. hysterophorus***

Property	Uses	References
<i>Traditional Medicine</i>	i) Used in case of diarrhoea, dysentery, fever, urinary tract infections, neurologic disorders, malaria and as emmenagogue ii) In some tribal community it is used to treat for skin rashes, rheumatic pain, herpes, inflammation, eczema, heart trouble, cold and gynaecological ailments iii) Pharmacologically therapeutic for neuralgia, active as vermifuge, and as analgesic in muscular rheumatism	Surib-Fakim et al. and Maishi et al. <sup>48,49</sup>
<i>Anticancer</i>	The major ingredient of the weed is Parthenin, exhibits important medicinal properties anticancer assets	Venkataiah et al. <sup>50</sup>
<i>Antidiabetic</i>	It is proved that type II diabetics who are insulin independent can be treated with the aqueous extract of <i>P. hysterophorus</i>	Patel et al. and Kar et al. <sup>51,52</sup>
<i>Antifungal</i>	Different extracts of <i>Parthenium hysterophorus</i> shows antifungal potential against human and animal fungal diseases	Rai et al. <sup>53,54</sup>
<i>Antioxidant</i>	Methanolic extracts can be used as natural antioxidants as it has high antioxidant property	Khan et al. <sup>55</sup>
<i>Antitumor</i>	Again it is reported that methanolic extracts of its flower has the potential to slow down the rate of tumor development	Ramos et al. <sup>56</sup>
<i>Antimicrobial</i>	Prevents the progress of rhizosphere flora such as <i>Rhizospirillum</i> , <i>azotobacter Rhizobium</i> and also can resist fungal and bacterial growth like those of <i>F. oxysporum</i> , <i>A. niger</i> , <i>S. aureus</i> , <i>C. albicans</i> and <i>E. coli</i> etc.	Kumar et al. <sup>43</sup>

### (b) Larvicidal properties

Root and stem extracts of *Parthenium* is reported to have larvicidal effects. This property can be utilized to control

larvae of different insects such as aphids and mosquitos. Such characteristics of *Parthenium* extract has potential to harm human health and crop plants respectively.<sup>57,58</sup> Chemical components extracted from leaves exhibited remarkable decline in reproductive capacity and lifetime of *Lipaphiserysimi*.<sup>57</sup>

### (c) Enhancement of crop productivity

The *Parthenium hysterophorus* is a good source of macro and micro-nutrients such as N, P, K, Mg, Ca and chlorophyll, thus can be used as substitute of compost.<sup>55</sup> However, this plant cannot be used directly because of its high quantity of essential oils and phenolic compounds. We can make a path towards sustainable organic farming by using *Parthenium* with water hyacinth in compost, offers a better weed control solution.<sup>59</sup> It is observed that *Parthenium* with *Eichhornia* enhances available nutrient content in the compost and decreases its harmful effects.<sup>59</sup> Phenolic components of *Parthenium* are strangely decreased in vermicompost. It reduces the percentage of heavy metal, toxic substances and organic carbon whereas significantly increases the macronutrients (N,P,K) content, which is appropriate for organic farming. There is significant reduction of weed concentration by *P. hysterophorus* extracts due to the suppression of cell division mediated by indole acetic acid and gibberellin which is expected to be accountable for its allelopathic power on nearby plants.<sup>60</sup>

The main volatile agent of *Parthenium* is Parthenin which have insecticidal and phytotoxic action against various insects like *Cassia tora*, *Callosobruchus aculatus*, *Spodoptera litura* and *Meloidogyne incognita*, and their larvae. Different derivatives of parthenin such as saturated lactone, pyrazoline adduct, and propenyl, displayed remarkable phytotoxic and nematocidal activities.<sup>61</sup>

### (d) Removal of heavy metal and dye

Environmental pollution with heavy metals and dyes has become a huge ecological nuisance because, both heavy metals and dyes have carcinogenic effects which is dangerous for human health. Therefore a cost effective substitute absorbents or technologies are essential for handling of contaminated wastewaters or industrial discharge in developing countries like India. *Parthenium hysterophorus* can be used as an agent for bioremediation of dyes and toxic metals. Cadmium (Cd) and nickel (Ni) are used in various industries, but *Parthenium* is also cheap and environmental friendly absorbent of such industrial discharge.<sup>17,59</sup> *Parthenium* has also demonstrated the capability to absorb Cu, Co, Zn and methylene blue dye from industrial discharge and wastewater. The absorbed extremely toxic metals by it can cause bone deformity, red blood cell (RBC) destruction, kidney disease and elevated blood pressure etc.

### (e) *Parthenium* as substrate for enzyme and biogas production

*Parthenium* is used to generate enzymes such as xylanases,<sup>62</sup> which can cleave xylans. The product obtained after xylan degradation have industrial applications like animal feed production, artificial sweetener, baking, for biofuel and textile industry, coffee extraction and clearing up of fruit juices. It can also be used in paper industries. High level of the enzyme production approves the possibility of

using *Parthenium* as an alternative carbon source for cheap enzyme production method.

*Parthenium hysterophorus* can be used as a substrate for the making of biogas. *Parthenium hysterophorus* was mixed with cattle manure at a 10% level and permitted to digest an aerobically at room temperature and significant increase in methane content was achieved. Considering the abundance of this weed and considerable cattle farming, *Parthenium* should be seriously considered as a substrate for biogas production in India. This will not only resist the spread of the weed but also useful and eco-friendly alternative of limited energy sources.<sup>63</sup>

### (f) Synthesis of nanoparticles

Parashar *et al.* reported that how silver nanoparticles can be synthesize by reducing silver ions existing in the aqueous solution of silver nitrate complex using the leaves extract of *Parthenium hysterophorus*.<sup>64</sup> These nanoparticles have various eco-friendly applications such as in wound healing, bactericidal and other medical and electronic applications, which makes this method potentially useful for the large-scale synthesis of other nanomaterials.

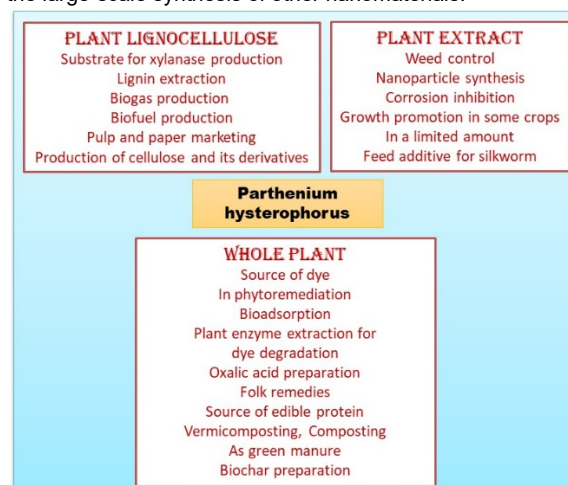


Figure 4: Beneficial aspects of *Parthenium hysterophorus*

## 5. Management practices

In general, *Parthenium* is an allergenic, pernicious, poisonous and violent weed that has hazardous impact on environment, humans, crops, and cattle. India has great risk from this weed as it grows luxuriantly in agricultural lands. So we should pay proper attention to find out the remedy to control *Parthenium*. Researches in India have proposed several cost effective control measures for this fast growing weed, which are summarized in figure 5 as follows:

### (a) Physical management

Small infested area can be isolated by early detection and an ongoing commitment is required to remove any seedlings that appear. Therefore the common and cheapest method is hand plucking, in which plants are uprooted before flowering.<sup>65,66</sup> However, this method may pose serious health hazard since direct human handling is involved and also seeds may spread during the handling which would increase

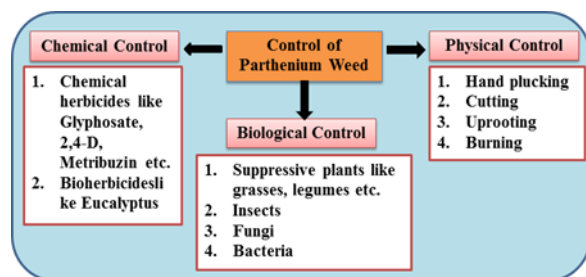


Figure 5: Management strategies of *Parthenium hysterophorus*

the area of invasion. It is also not very efficient as constant removals are required over an extended period of time which is very laborious task.<sup>67</sup> Burning can also be used to control the spread of *Parthenium*, however, it is also not very helpful as it destroys only those seeds which are close to the soil surface but the seeds protected under the soil remain unaffected by fire<sup>68</sup> and it also deteriorates soil value by rendering it more alkaline and lacking in organic matter.<sup>69</sup> So far, very few governmental steps have been taken to control the *Parthenium* weed in developing countries. *Parthenium* weed were placed into an agricultural pest category in 1969, by the State of Karnataka (in India), but this lawmaking could not be enforced and therefore was unable to stop its spread to other States.<sup>70</sup> Grazing control is the most useful method to control the *Parthenium* spread on a large scale but this practice has not been implemented effectively in India. Alternatively, pasture spreading can be useful for rehabilitation of pasture lands which might be more effective than simply reducing the weed.

### (b) Chemical Management

Chemical treatment of this weed *via* herbicides is very useful and is recommended at an appropriate time *i.e.* at preflowering stage. In certain circumstances such as in public parks or on small areas or in the areas of high value crop cultivation chemical treatment of this weed is financially feasible. However, in the vast areas of wastelands or within the forests areas where the weed is commonly found chemical control is not feasible or cost effective. It is very necessary to use selective herbicides that do not destroy other species.<sup>71</sup> Chemical herbicides which are commonly used in the chemical management of *Parthenium* are glyphosate, atrazine, bromoxynil, common salt, 2,4-D amine, 2,4-D ester, Floumeturon, Hexazinone, Metribuzin, Norflurazon and Paraquat.<sup>72,73,74,75</sup> The rosette stage is the right time to apply post emergent herbicides and it is also necessary to monitor the treated area. The herbicides need to be in place during all times of the year when the seeds are expected to develop. Very effective treatments for *P. hysterophorus* control were noticed using metribuzin and glyphosate and the cheapest method of control is spray of common salt solution (at ~ 20% concentration) in open waste land, along railway tracks etc. However, it is a matter of great concern that, long term exposure to chemical treatment may potentially impart herbicide resistance within the weed community. *Parthenium* weed has already developed a resistance to ALS-inhibiting herbicides and glyphosate.<sup>76</sup> Bioherbicides can be used in place of herbicides such as Eucalyptus oils may be used as natural herbicides for the

biocontrol of *P. hysterophorus* owing to its allelochemicals.<sup>77</sup> But bioherbicides were found to be less effective compared to chemical herbicide till date.

### (c) Biological management

Biological management may prove to be the most cost-effective process to control *Parthenium*. Beneficial plants that could suppress the growth of *Parthenium* weed were initially undertaken in India. Studies have shown that a number of grasses viz., *Cenchrus pennisetiformis* Hochest, *Dicanthium annulatum* Stapf, and *Sorghum halepense* Pers. and legumes can suppress the spread of *Parthenium* through competitive displacement.<sup>78</sup> Other suppressive plants that help to control the overgrowth of *Parthenium* are one-leaf senna (*Cassiauniflora* Mill.), *Imperata cylindrical* (L.) Beauv., *Desmostachya bipinnata* Stapf, *Clitoria terneata*, *Digitaria milanjana*, *Tagetes erecta* and *Cassia sericea*.<sup>79,80</sup> Bioherbicide and naturally suppressive plants can synergistically act together to reduce the reproduction and spread of this weed.

Insects, fungi and bacteria can also be introduced to suppress the growth of the weed. Some insects are found to be valuable in controlling the weed are stem galling moth *Epiblema strenuana*, Bucculatrix parthenica (leaf-mining moth), Smicronyx lutulentus (seed-feeding weevil), stem boring weevil *Listronotus setosipennis* and Zyogramma bicolorata (leaf-feeding beetle, Figure-6).<sup>81</sup> The moth's larvae feed on the stem of *Parthenium* and forms ball which slow down the plant growth. Fungi such as *Puccinia abrupt* var. *parthenicola* and *Alternaria alternate* can also be used for biological control of *Parthenium* weed.

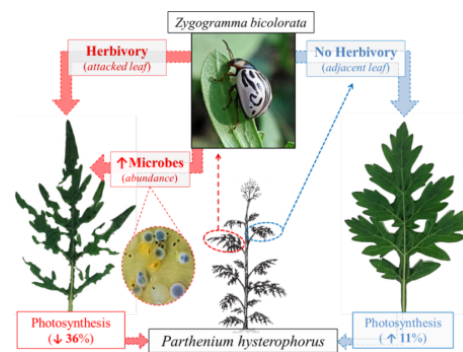


Figure 6: Control of *Parthenium* weed using *Zyogramma bicolorata*

### (d) Control by the excess use of the weed

The best strategy in controlling this weed is its excessive utilization as it is well documented for beneficial properties like insecticidal, nematicidal and herbicidal activities. It can also be used for biogas production, ethanol production, nanoparticle synthesis, silkworm feed additives, mulching, paper and compost.<sup>64,82,83</sup> Its use as a green manure, should be promoted. As India has vast area of cultivation people should use *Parthenium* as a compost, which in one way cost effective and in other way it can control it. So in the developing countries like India, the Government should take

necessary action for this practices where application of other alternative is expensive and difficult.

### Conclusion

In this review article we have discussed various aspects of *Parthenium* weed and the major challenges are in control of this weed as it has allelopathic and negative impacts on crop plants and livestock. To solve this crisis, public support and consciousness has to be established; cooperation of stakeholders to stop the spread of its seeds; improved integrated control and economically feasible management practices should be adopted. Through the implementation of effective and efficient management practices we can overcome the adverse influence of *Parthenium* on agriculture, environment and the human health. Synthesis of silver nanoparticles using silver nitrate complex and the extract of *P. hysterophorus* by Parashar *et al.* can promote this noxious plant into a valuable weed for nanotechnology-based industries in future. "Control through utilization" is the best way and it can be reached through joint efforts of farmers, researchers, governmental and non-governmental agencies. In this regard, the well-known intolerable *Parthenium* will become a boon for the human beings and for all other things in near future. But we should keep this practice not only for the *Parthenium* but it should be applied for other weeds also.

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