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PARTHENIUM HYSTEROPHORUS: A GLOBAL MENACE AND POTENTIAL RESOURCE - UNDERSTANDING ITS INVASION, IMPACTS, AND MANAGEMENT STRATEGIES

Nidhi Sharma[1], Rohit Nadda[2]
[1]M.Sc. Environment Science (Ecological Sciences) 2nd semester, Department of Environment and Sustainable development, Banaras Hindu University, Varanasi.
[2]Junior Resident, Department of PSM, DRPGMC Kangra at Tanda, Himachal Pradeh

----------ABSTRACT----------
Parthenium hysteropherus weed is the world's most aggressive invasive weed which is a cause of major losses to the agroecosystems, ecology, economy, and societies of more than 40 countries from the 1900s. Parthenium has several attributes like high success rate, high adaptability to diverse environments which are responsible for its invasiveness. At the global level, various physical, chemical, and biological control measures are used to control parthenium but all these methods owing to several limitations. Because of which its management still remains as a big challenge. From the past decade, more research focus is on its utility potential. Hence now we know the utility potential of Parthenium in diverse fields. In agriculture, it can be used either after composting or as a PBC parthenium biochar. In a wastewater treatment plant, it can be used to extract particular heavy metals and dyes at 99% efficiency. So with our knowledge and capacity to exploit this weed in diverse fields, we must utilize it at a large scale and give our contribution to its strategic management across the country on a sustainable basis. This review briefly discusses the problems associated with parthenium and its various utility potentials which can create new avenues for parthenium management effectively.

KEYWORDS: *Parthenium hysterophorus, biological control, integrated management, utility potential, biochar, adsorbent, biogas, biofuel.*----------

INTRODUCTION

Parthenium weed is native to South America, North America, and Central America. This weed originated in the Gulf of Mexico by natural hybridization between parthenium confertum and Parthenium bipinnatifidum. [Nath R. et.al.] Parthenium exists in two different races in its native range: North American race & South American race. The North American race is Parthenium hysteropherus which has been introduced as a highly prolific weed in most countries worldwide. South American race differs from North American in morphological characteristics such as yellow flowers and having **Hymenin** as dominant sesquiterpene lactone. Whereas the North American race has white flowers with **Parthenin** as the dominant sesquiterpene lactone. **Parthenin** is a water-soluble phenolic compound that inhibits the germination and growth of a wide variety of crops. This weed is an annual ephemeral herb, which belongs to Asteraceae family. Parthenium weed has a short-life cycle which is of 4 to 6 weeks. This weed produces flowers and seeds until it dies. Its seed productivity is also very high i.e. one plant can produce 15,000 to 1,00,000 seeds during rainy season. Parthenium complete 3 to 4 life cycles or more within a year, which varies with regions. Its seeds are lightweight and so get easily dispersed across large distances by means of vehicles, grains, machinery, feedstock, and to short distances through wind and water. Seeds are largely viable in subsoil conditions as well as above soil. They also show strong regenerative capability which makes Parthenium hysteropherus highly **fecund** weed, hence show high growth and biomass production. There are many factors responsible for the rapid establishment of parthenium weed in new areas, but one of the major drivers is the lack of its natural enemies in the introduced area (Bajwa et al. 2016). The normal germination period of parthenium is in summers when it is warm and there is huge amount of rainfall, in spring it starts flowering when just 1 month old, continuously flower for the next 6 to 8 months, and then

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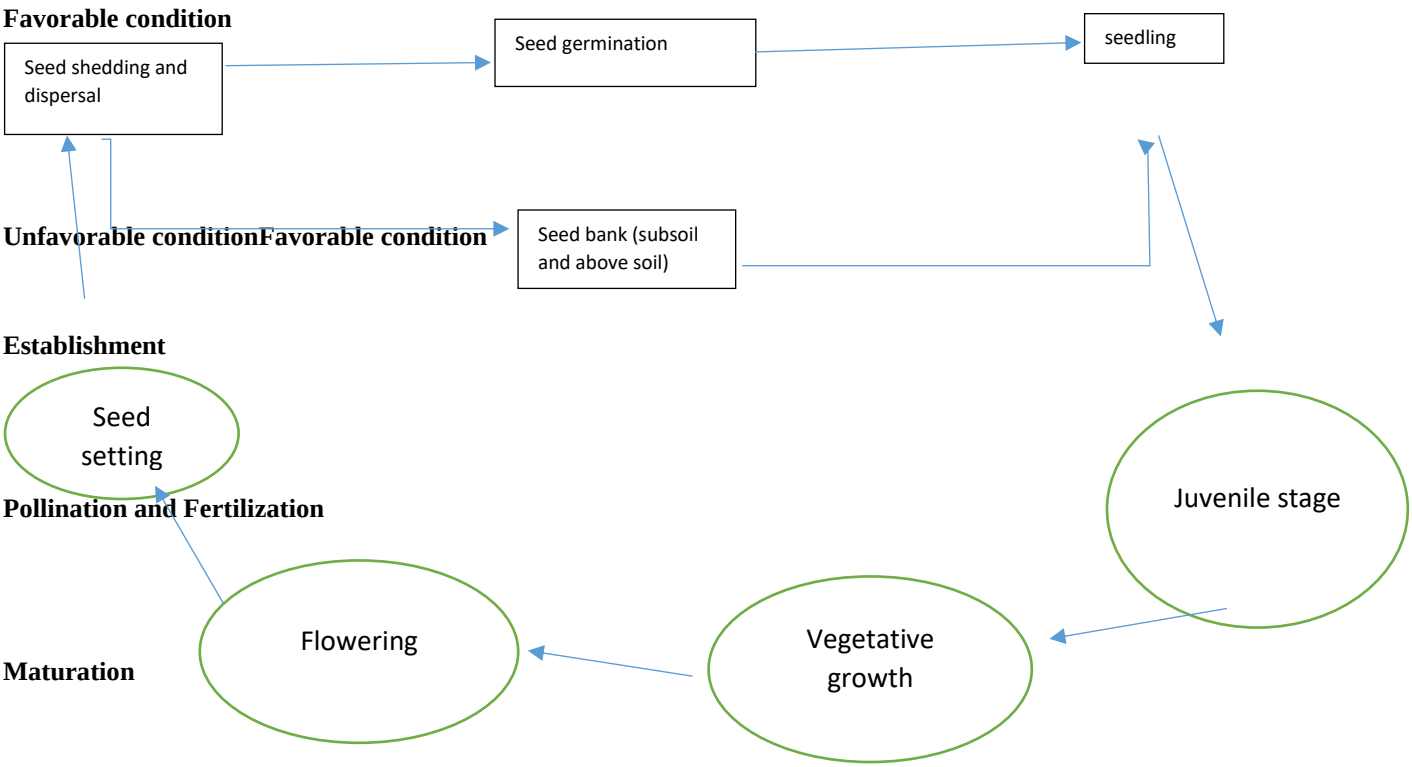
dies in late autumn. However, parthenium can germinate, grow and flower over a wide range of temperature and photoperiods and so it can be seen growing at any time of the year in different types of habitats and in different stages of its life cycle in the introduced field. Because of all these reasons parthenium has become a **Global Invasive Species**.**[Shabbira, A., et.al.]**

In the last century, it has invaded more than 40 countries including Australia, India, Pakistan, Nepal, Bangladesh, Sri Lanka, Bhutan, Malaysia, China, Vietnam, Japan, Israel, Oman, Yemen, Hawaii, Papua New Guinea, Ethiopia, Uganda, Tanzania, Kenya, Madagascar, Mozambique, Zimbabwe, Egypt and many more. Parthenium during this decade infested almost all parts of the world. In introduced areas such as India, Parthenium is popularly known by different names such as **congress grass, carrot grass, santa maria, bitter weed, star weed, white top, wild feverfew, gajar ghas, and the "scourge of India".** In India, there are 3 "hotspots" of its invasion: western Himalaya, peninsular India, and North-east India. In India, this weed has the potential to take over 65% of the land. Although it has already occupied more than 6 million hectares of land in India. Due to its presence in agricultural fields, it has been causing a 40% reduction in crop yield every year. [Nath R. et.al.]

LIFE CYCLE OF Parthenium hysteropherus



Detrimental impacts of Parthenium hysteropherus

Parthenium consists of lots of secondary metabolites within its aerial parts that is leaves, flowers, seeds, pollens, trichomes, hairs, and underground parts that is roots and root hairs. These secondary metabolites help plant in defence against herbivory, pathogens and competing with other plants. [Adkins, S. et. al.] Because of these allelopathic effects shown by some chemicals of this plant, those chemicals or secondary metabolites are known as allelochemicals.Residues of parthenium plant parts containing allelochemicals, when degrade in soil, release these harmful allelopathic chemicals into the surrounding soil.

Possible allelochemicals reported from different parts of the parthenium weed plant are:

1). Sesquiterpene lactones allelochemical present in the stem and leaves of Parthenium which consists of chemical constituents like Parthenin, caffeic acid, p-coumeric acid.

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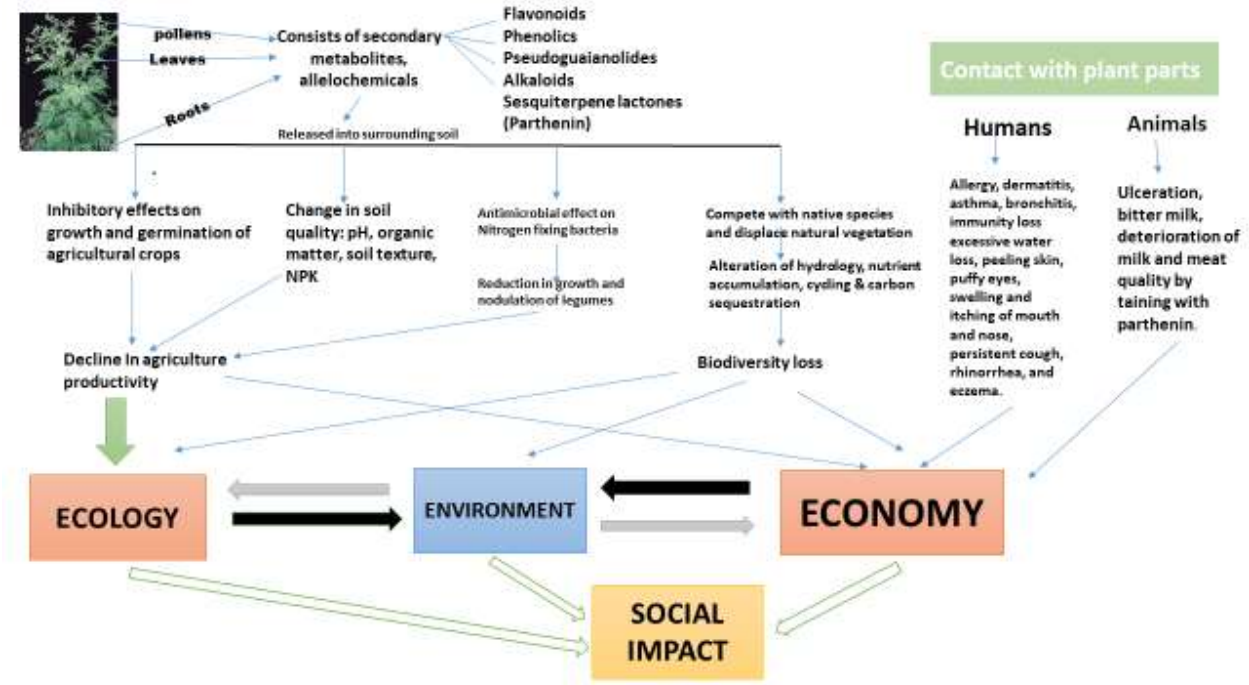
2). Phenolic acids allelochemical present in the root and leaf part of Parthnium with composition of Ferulic acid, anicic acid, vanicillic acid, fumaric acid.
3). Sesquiterpene lactones allelochemicals present in the stem portion, flowers and trichomes of Parthenium with coronopolin as chemical constituents.
4). Minor sesquiterpenes present in the flowers of Parthenium as ambrosonalides, 2B-hydroxycoronopilin, and 1, 3-hydroyparthenium chemicals.
5). Sesquiterpene lactones in the stems and leaves as pseudoguananolodes.
6). Sesquiterepene lactones in the stems as hystrin as chemical.
7). Flavonoids in the aerial parts as aglycone flavanols.
8). Seco-pseudoguananolides present in the all parts of Parthenium as charminarone chemicals.
[Kushwaha, V. B]

These chemicals when released in soil shows phytotoxic effects which inhibit growth and germination of nearby crops, vegetation, pasture species, and native species. One of the main allelopathic chemical found in plant is "Parthenin". Parthenin is a water soluble phenolic compound that inhibit germination and growth of a wide variety of crops.

They change soil quality, show antimicrobial effects on Nitrogen fixing bacteria & so reduce legumes growth in agricultural fields. Compition between native species and parthenium occurs, which results in displacement of native species by parthenium. All this lead to decline in agricultural productivity and biodiversity loss.This plant contact with humans and animals cause number of diseases like in humans, contact with plant and pollen causes allergic responses such as heyfever, dermatitis, asthma, skin rashes, puffy eyes, swelling, itching of mouth and nose and other respiratory disorders. Hence eventually, Parthenium is impacting ecology of ecosystem, environment of ecosystem and humans of that particular area in a very negative way, which is resulting in declining effects on national economy. All this is eventually threatening three pillars of sustainability. Hence it becomes very imperative to control its spread in time.



Flow diagram showing how allelopathic chemicals of parthenium threatening the 3 pillars of sustainability

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Parthenium hysteropherus in agricultural fields compete for space, food, sunlight, nutrients, and water with native agricultural species. It affects many crops, particularlythe cereal crops like Triticum aestivum, Zea mays, eragrotis tef Zucc. Trotter, Oryza Sativa L., Sorghum bicolor L., in various countries of world. In India yield of these crops has been reported to decrease by 40% every year. Whereas by 27% in Ethiopia. This has created a biggest threat to food security of India and various other countries as these crop possess a significant proportion of the national food.

MANAGEMENT OF Parthenium hysterophorus

Various **physical and chemical methods** are used to control this weed but they have number of limitations and are not effective in long term. Most effective approach for long-term control of this weed is INTEGRATED WEED MANAGEMENT, in which biological methods like use of suppressive plants or bio-herbicides or competitive plants are complemented with strong legislative measures. **[Shabbira, A., et.al.]**

Physical control: The Parthenium hysteropherus plant can be managed either by controlling or by utilizing for number of benefits provided by it. Although it's a weed, it has enormous agricultural, pharmacological, industrial, and medicinal benefits. Hence this plant can prove to be rally beneficial for us. But, unfortunately, this plant is mostly controlled by various physical and chemical methods. Physical control methods like manual removal, hand pulling, hoeing, fire burning are used. But these physical methods have number of limitations like they are not cost effective, are labour intensive, affect health of the workers who manually pull them apart, or these removed plants or partly pulled plants regrow from cut**. [Adkins, S., et. al.]**

On the other hand **chemical methods** such as use of weedicides and herbicides like glyphosate; paraquat; metsulfuron; 2,4-D; atrazine; anilofos; alachlor; bromoxynil; common salt, etc. also show number of limitations. Use of chemicals requires knowledge of when to apply that is time of application and how much dose to apply. Another problem with this is that some are effective at pre-emergence stage whereas some are at post-emergence stage, hence need to take care of that as well. Plus use of herbicides is economically expensive, hence it becomes difficult for farmers to control parthenium chemically. Parthenium weed also has the ability to develop resistant to long term chemical use. Already it **has developed resistance**to **ALS-inhibiting herbicides** and **glyphosate.**

[Adkins, S., et. al.]

Another way to control parthinium is by **biological control measures**. Methods to control Parthenium biologically arequite better than chemical and physical methods. In this approach we can use **suppressive plants** fore.g. one-leaf senna (Cassiauniflora Mill). **Bioherbicides** fore.g. Zygogrammabicolorata, Dicanthusannualatum, Tagetuserectus, Alliumcepa, Cinnamomumcamphora,stem Galling mouth (Epiblema strenuana), etc.and some mycoherbicide are also known to cause rust in parthenium or **competitive replacement** fore.g.Mirabilisjalapa,Amaranthusspinosus, Cassia sericea, etc. and Parthenium is suppressed by some competitive replacement plants in India like cassia Tora and cassia Seracia marigoldplant.

Despite all these physical, chemical and biological methods, the most effective approach for its long term control is integrated weed management, in which suppressive plant species(Astrebella squrossa and Clitoria ternatea) in combination with parthenium leaf feeding beatle - Zygogrammabicoloratacan reduce parthenium weed height by 46%, biomass by 66%, and seed production by 95% [Shabbir A., et. al., 2018].50-100 beetles per plant are enough for this.

[Shabbira, A., et.al.]

UTILIZATION POTENTIAL OF PARTHENIUM HYSTEROPHERUS

Another method to manage Parthenium hysteropherus is by **utilizing** it for number of benefits. It can be managedby its utilization in number of diverse fields.

1).Biochar prepration from Parthenium hysteropherus – Parthenium biochar compost (PBC): We can convert parthenium to biochar through pyrolysis, which when added to soil, increase soil quality and crop yield. Best Parthenium biochar can be made thermally at 330-350 degree Celsius for 35 to 40 minutes residence time. During this pyrolytic conversion, an allelochemical- **ambrosin** is lost. Parthenium biochar addition to soil showed increase inseedling vigour index, soil dehydrogenase activity, catalase activity, whereas decrease in hydrolytic enzyme activity

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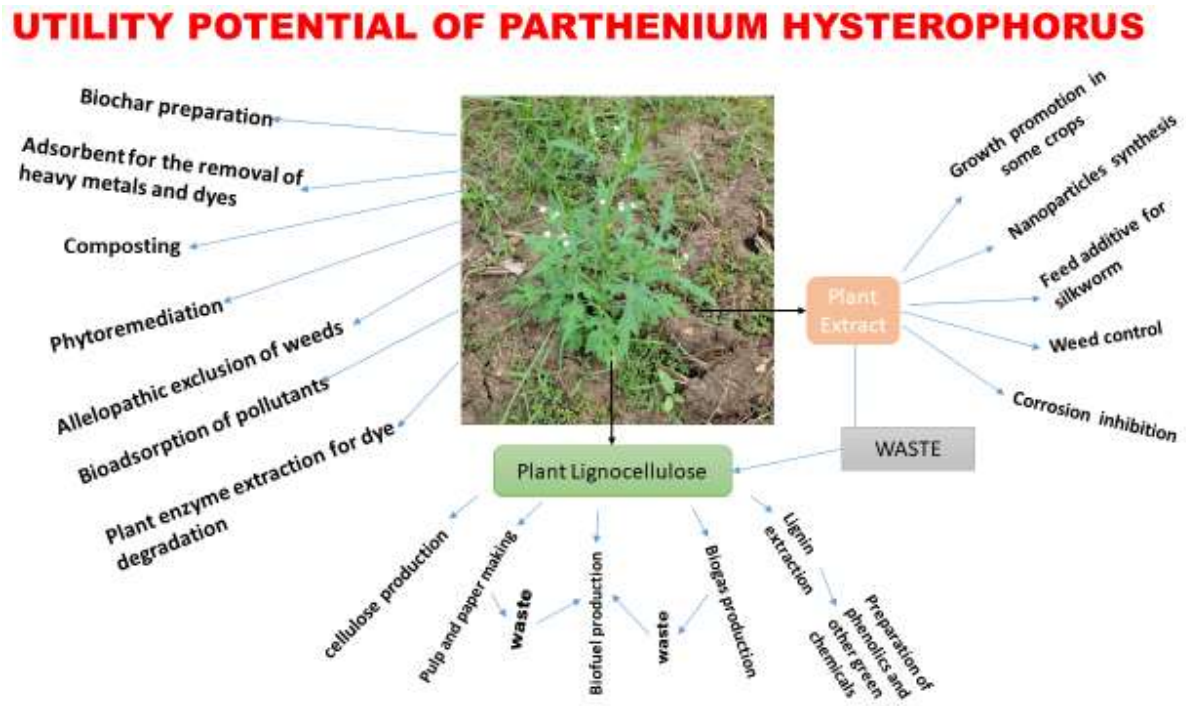
like acid and alkaline phosphates, decrease in metabolic quotient, whereas increased basal soil respiration up to 20g/kg PBC for Zea mays plantation. And no adverse effects even at high levels of Parthenium biochar addition. As temperature of pyrolysis increase, biochar yield decrease but stability increases, however low temperature pyrolysis condition is quite good for PBC application in soil and agricultural crops. .
[Kumar, S., 2013].

2). Parthenium, In the form of powdered weed, activated carbon, and ash, is capable of adsorbing 90% of some of heavy metals and dyes from waste water.
Experiments done by **kadirvelu et. al., (2002)** came with the findings that Nickel (II) and Mercury (II) metals are successfully recovered by their adsorption on activated carbon made of whole parthenium weed.
Cadmium (II), chromium (IV) and chlorides (I) are successfully adsorbed by dried powder of parthenium weed with 99% efficiency. **[Ajmal et al., (2006); [Apte et al., (2011)]**

For 90 minutes retention time Methylene blue, Malachite green, Rhodamine B, Procion orange, and Acid violet dye with 17 other dyes successfully eliminated from waste water with 99.9% efficiency. .
[Sivaraj and Subburam, (2002)]
Rhodamine B dye is experimentally removed with 99.2% efficiency at pH 7.0 by sulphuric acid treated parthenium carbon**.** **[Lata et al., (2008)]**
Use of green biomass obtained from parthenium to adsorb Malachite green dye from waste water by using sulphuric acid and phosphoric acid.**[Lata et al., (2008)]**
Charred biomass of weed has 99.9% efficiency of removing Methylene Blue dye. .
. **[Chatterjee et al., (2012)].**



. **[Shabbira, A., 2018]**

3). Parthenium as compost: Due to presence of Histamine and free amino acids, parthenium can be used as a compost or as green manure in agriculture. Its compost consists of plenty of nutrients like NPK, Fe, Zn, Mn, Cu, which make it two times richer than farmyard manure. Better compost is obtained in preinflorescence stage. Effect of compost has

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been intensified by addition of useful bacterial species like Azotobacter chrococcum.Compost and manure made from parthenium is rich in potassium this menu suppresses the growth of the grains other weeds. Parthenium compost's nutrient composition is higher than farm yard manure (FYM). Application of 50% parthenium compost in combination with 50% urea in presence azotobactor bacteria, results in very high crop yields**.**
[Kishore, P., et. al. 2010]

4). Parthenium can be used to increase silk production because Silkworm larvae is tolerant to parthenin toxin of this weed, and when these silkworm larvae are fed with parthenium root extract diet they showed increased cocoon yield which eventually increased silk production.. .
[Shabbira, A., 2018]

5). It can also be use to make cellulose, Parthenium hysterophorus represents rich source of lignocellulosic biomass, which is used as a substrate for the production of water soluble alpha-cellulose, which can be further modified to obtain various derivatives. **[Saini, A., 2014]**

6). Parthenium weed is also an attractive substrate for producing second generation biofuels. Lignocelluloses present in Parthenium is pretreated with acids at very high temperature has shown autohydrolysis to a mixture of sugars, with xylose being predominant, which can be fermented then to ethanol. **[Saini, A., 2014]**

7). Biogas production from Parthenium can be a best alternative for its utility as this burns hundred times better than any fossil fuel. So why can't we make energy from this most invasive weed and help planet to get rid from Green House Gases using world's most invasive weed.. **[Shabbira, A., 2018]**

Useful biological effects and activities of Parthenium hysteropherus.

- It shows hypoglycemic effect**, [Patel, V. S. et.al.]**
- Thrombolytic activity (useful in migraine treatment),**[Mamun, R. A., et.al.]**
- It is effective against dengue parasite,**[Kumar, S., et.al.]**
- Shows antitrypanosomal activity,**[Talakal, T. S., et.al.]**
- Has anticancerous activities,
- Shows antibacterial, antiviral (e.g., against potato virus), and antifungal activity.

CONCLUSION

Parthenium ability to produce high number of pollens, ability to adapt in diverse range of niches and its repulsive behavior towards native species due to presence of allelochemicals, is responsible for its invasion all around the world. Several physical and chemical methods used worldwide are not fully successful in controlling and managing parthenium weed. Moreover, it is need of the hour to design eco-friendly and economically sound methods for strategic management of Parthenium.

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