Chronicle of Bioresource Management 2023, 7(3):053-060

Chronicle of Bioresource Management
An International E-magazine

September, 2023 *Popular Article*

Open Access

Corresponding Author
S. Vijayakumar
e-mail: vijitnau@gmail.com

Citation: Vijayakumar et al., 2023. *Parthenium hysterophorus* and its Management in Crop and Non-crop Environment. Chronicle of Bioresource Management 7(3), 053-060.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

Keywords:

Invasive weed, *Parthenium hysterophorus*, weed management

Article History

Article ID: CBM4857
Received on 21st August 2023
Received in revised form on 05th September 2023
Accepted in final form on 15th September 2023

Parthenium hysterophorus and its Management in Crop and Non-crop Environment

S. Vijayakumar[1*], P. Saravanane[2] and Rubina Khanam[3]

Abstract

Parthenium hysterophorus, commonly known as Gajar ghas, has exhibited rapid proliferation throughout India, encompassing approximately 35 million hectares of land. Its invasive and aggressive behavior has precipitated a host of health concerns, diminished biodiversity, and negatively impacted agricultural productivity. While the government has launched initiatives to combat its spread, their efficacy remains constrained by the widespread lack of public awareness. The Indian Council of Agricultural Research (ICAR) diligently conducts annual awareness weeks, imparting knowledge about various control strategies to the public. To effectively confront the menace posed by *Parthenium hysterophorus*, it is imperative to employ comprehensive mass media campaigns, involving collaboration with non-governmental organizations (NGOs) and private entities. These concerted efforts are indispensable in addressing the multifaceted challenges posed by *Parthenium hysterophorus* and mitigating its adverse effects on human health, biodiversity, ecosystems, and agriculture.

1. Introduction

Parthenium hysterophorus, a member of the Asteraceae family, is recognized globally as parthenium, carrot weed, white top, and congress grass. In India, it is commonly referred to as Gajar ghas (Figure 1). Parthenium has established its presence across diverse ecosystems, spanning agricultural fields, forests, grasslands, and urban spaces. Notably, it exhibits aggressive colonization pattern, particularly in areas with depleted ground cover and exposed soil, such as fallow wastelands, roadsides, and overgrazed pastures amidst existing plant cover and weed populations. Interestingly, it is not initially listed among the world's most problematic weeds documented by Holm et al. during 1970s but, at present, it is now considered one of the seven most detrimental weeds globally (Kaur et al., 2014). Originating from South and Central America as well as the Caribbean, parthenium has transcended its native

Author's Address

[1]ICAR-Indian Institute of Rice Research, Rajendranagar, Telangana (500 030), India
[2]Professor, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal (609 603), India
[3]ICAR- National Rice Research Institute, Cuttack (753 006), India

Figure 1: *Parthenium hysterophorus* plant

range, infiltrating numerous countries across the globe-excluding the European continent. Recognizing the gravity of its invasiveness, the Karnataka Government has taken proactive measures to curb parthenium spread by including it into the Pest Control Act of 1979. This legislative action aims to thwart the spread and establishment of this invasive species within the region. The transformation of parthenium from a relatively obscure plant to a globally recognized invasive species underscores the urgency of collaborative efforts in managing its impact on various ecosystems, agriculture, and human health.

2. Ecology of *Parthenium hysterophorus*

Parthenium robust growth across a diverse range of ecological conditions can be attributed to the following characteristics:

➢ Adaptability: It has a distinctive ability to thrive across diverse agro-climatic and soil conditions, marking it as an exceedingly adaptable species.

➢ Soil Suitability: Its growth is notably luxuriant in black soil, where it often establishes itself with vigor.

➢ Survival: It seeds possess a remarkable resilience, capable of enduring single frost temperatures as low as -2°C. Tolerance to wide range of pH: This invasive plant showcases its adaptability to survive by flourishing within an extensive range of soil pH levels. It can grow in soils with pH ranging from 2.5 to 10. However, for optimal germination, the range of 5.5 to 7.0 pH is most favourable.

2.1. Special Features of Parthenium hysterophorus Which Makes it More Aggressive

Parthenium exhibits distinctive traits that contribute to its aggressive colonization includes Photo-Thermo insensitive: Parthenium growth is not restricted by day length, allowing it to thrive regardless of photoperiod conditions. Temperature Insensitivity: The plant's growth is largely unaffected by temperature fluctuations, enabling it to flourish across a wide range of thermal conditions (Saravanane et al., 2023). Physiologically, parthenium is C_3/C_4 intermediate. It is interesting to note that parthenium possess a C_4 metabolism at young rosette leaf stage and then the photosynthetic carbon fixation pathway is converted to C_3 metabolism during the later growth stages (Tang et al. 2009). Seed Dormancy: Parthenium seeds can display varying degrees of dormancy, enhancing its adaptability to different environments. High Colonizing Capacity: With an innate ability to rapidly colonize new areas, parthenium can establish in diverse habitats. Vigorous Regeneration: Parthenium exceptional capacity for regeneration allows it to grow even from severed parts, further contributing to its invasive potential. Prolific Seed Production: The plant's impressive seed production capabilities, yielding as many as 5,000 to 25,000 seeds per plant, enable rapid population growth. Prolific seed spread: Parthenium light weight seeds possess a unique floating mechanism, facilitating long-distance dispersion through both water and wind. Allelopathy Effects: Parthenium exhibits allelopathic effects, negatively impacting competitor plants, including those of the same species, thus bolstering its competitive advantage (Bashar et al., 2023). These exceptional attributes collectively enhance parthenium ability to establish, proliferate, and dominate ecosystems, emerging as an aggressive and problematic invasive species.

3. Global Spread of *Parthenium hysterophorus*

3.1. South America

Parthenium has been reported in Southern Brazil, Uruguay, and Northern Argentina. Surprisingly, despite its close proximity to its native range, it isn't a major weed in North, Central, and South America. Factors such as unfavourable climatic conditions, widespread herbicide usage, and competition from other aggressive weeds may have limited its spread in these areas.

3.2. North America

Parthenium is found in Mexico and the USA but not in Canada. Its presence extends from Florida to Texas, reaching as far north as Massachusetts, Pennsylvania,

Table 1: Biology of *Parthenium hysterophorus*

Scientific name	*Parthenium hysterophorus* L.
Origin	Central and N. America, Invaded large area of India
Introduction to India	Commercial trade from USA, believed to have come with Mexican wheat consignment (1950) under PL 480 Scheme, and first sighting at Pune
Pathways of spread	Wind, water runoff, transport of grains and vegetables, garden waste etc.
Propagation	Propagates by seeds and completes its life cycle within 3-4 months
Leaves	Leaves are simple, pubescent on both side but more on upper side. Venation is more prominent on lower side.
Stem	The stem is whitish, green, hairy, angular, longitudinally grooved. Whitish hairs covering whole body of the plant called trichomes
Growth habit	It is an erect, much-branched, aromatic, annual, herbaceous plant with a deep tap root. Can grow to a height of 0.5-1.5 m and very rarely up to 2 m
Flower heads	Flower heads are both terminal and auxiliary. Each head consists of five fertile ray florets and about 40 male disc florets

Ohio, Michigan, Illinois, Louisiana, Missouri, Kansas, and even the port cities of Baltimore, Maryland, and Virginia.

3.3. Australia

Parthenium was first reported in Australia in 1955 and has since spread widely across grazing lands in the Northern Territory, Queensland, and Northern New South Wales. Its impact is notable, causing direct losses of A$14-18 million to the grazing industry and A$16 million per year to the cattle industry.

3.4. Africa

Across Africa, parthenium has been documented in Madagascar, Mozambique, Swaziland, South Africa, Mauritius, Seychelles, Kenya, Ethiopia, Somalia, and Zimbabwe. In South Africa, it achieved invasive status only during the 1980s. Its presence has been observed in the eastern subtropical region of KwaZulu-Natal, Durban, Pretoria, and even the renowned Kruger National Park. Introduced into Ethiopia during the border conflict with Somalia around 1977, it now covers approximately 12 million hectares of Ethiopian land.

3.5. Asia

Parthenium is reported in countries like India, Pakistan, Bangladesh, and Nepal. In Sri Lanka, it was first reported in 1987 and observed abundantly in 1999. It has also spread to regions in southern China, Taiwan, and Vietnam. Notably, it hasn't been reported in Malaysia, Singapore, and Indonesia.

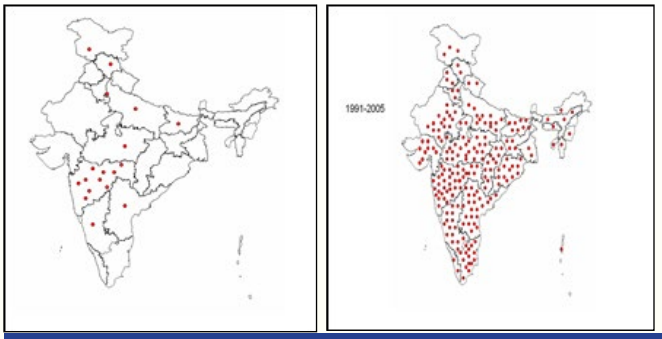
3.6. Europe

As of now, parthenium hasn't been reported in Europe.

3.7. Indian scenario

In India, parthenium made its entry through wheat imports in the 1950s. Its first reported occurrence was in Pune in 1955. Since then, it has invaded approximately 35 million hectares of Indian land, underscoring its pervasive impact. The global spread of parthenium highlights its invasive nature and underscores the need for strategic management strategies to curtail its detrimental effects on ecosystems, agriculture, and human health.

3.8. Comparison of Parthenium hysterophorus spread in India from 1955 to 2005



1955-1970 1991-2005

4. Hazards Caused by *Parthenium hysterophorus*

4.1. Health Hazard of Parthenium hysterophorus

Parthenium poses non-quantifiable risks, including dermatitis, anorexia, and intestinal damage. These risks can escalate to fatal outcomes among livestock such as buffalo, cattle, and sheep due to the presence of sesquiterpene lactone parthenin. Allergic Reactions:

In Bangalore, Karnataka, about 70% of the population suffers from allergenic rhinitis, while 47% grapples with nasobronchial allergies. This underscores the pervasive impact of parthenium allergens on human health. Tainted Animal Feed: Animal feed contaminated with parthenium exacerbates the issue. The presence of parthenin, a hepatotoxic compound, in tainted milk is concerning. When hepatotoxic parthenin interacts synergistically with copper, it can contribute to the onset of Indian Childhood Cirrhosis (ICC), a severe liver disease. These health hazards emphasize the imperative of effective parthenium management to safeguard both human and animal well-being, mitigate allergenic risks, and prevent the contamination of vital food resources.

4.2. Agricultural Hazards of Parthenium hysterophorus

Germination and Growth Inhibition: Parthenium exerts a negative influence on agriculture by suppressing the germination and subsequent growth of a wide spectrum of crops, encompassing pasture grasses, cereals, vegetables, other weeds, and tree species (Fig 2). Parthenium has found to invade the major crops like rice, wheat, maize, sorghum and other crops in various parts of India and world. Sorghum Grain Loss: The cultivation of irrigated sorghum in India is susceptible to considerable losses, with potential grain loss reaching almost 30% due to the presence of parthenium. If parthenium is left uncontrolled in sorghum throughout the season, grain yield losses can vary between 40 and 97% (Tamado et al. 2002). Maize Yield Reduction: Parthenium pollen deposition can disrupt the seed set process, contributing to an alarming yield reduction of approximately 40% in maize crops within India. Legume Growth Inhibition: Parthenium interferes with the growth and nodulation of leguminous plants, hampering their development and productivity. Forage Yield Decline: The impact of parthenium is especially pronounced in grassland ecosystems, leading to a substantial decline of up to 90% in forage production. Host for Crop Pests: Parthenium serves as an alternate host for various crop pests, potentially exacerbating pest-related challenges and their impacts on agricultural output. These agricultural hazards underscore the pressing need for effective management strategies to counteract the adverse effects of parthenium on crop growth, yield, and overall agricultural productivity. Addressing these challenges is pivotal for maintaining sustainable agricultural systems and ensuring food security.

4.3. Ecological Hazard of Parthenium hysterophorus

Flora Replacement and Suppression: Parthenium exhibits a tendency to outcompete dominant plant species and suppress natural vegetation across a diverse array of habitats. This trait poses a substantial threat to biodiversity jeopardizing the ecological balance within these ecosystems (Fig 2). Forest Land Invasion: Parthenium invasive nature extends to forest lands, resulting in the encroachment of these areas. It poses a significant challenge, particularly in forest nurseries, disrupting natural regeneration processes. Allelopathic Effects: Parthenium allelopathic effects have adverse consequences on the growth and survival of vital multipurpose tree species such as *Acacia leucocephala, Casuarina equisetifolia, Eucalyptus tereticornis*, and *Leucaena leucocephala*. Pastureland transformation: Within pasture lands, parthenium replaces indigenous grasses and weeds. This takeover not only impacts the overall composition of these ecosystems but also disrupts forage availability for livestock. These ecological hazards emphasize the crucial need for robust management strategies to mitigate the negative ecological impacts of parthenium invasion. Preserving biodiversity, maintaining healthy ecosystems, and safeguarding natural habitats demand a proactive approach to control and manage this invasive species.

Figure 2: Agricultural and ecological hazards of *Parthenium hysterophorus*

5. *Parthenium hysterophorus* Management

"Prevention is better than cure"

1. Manual/mechanical method
2. Chemical method

3. Biological method
4. Legal method
5. Utilization method
6. Integrated methods

5.1. Manual/mechanical Removal

Manual weeding has long been employed as a traditional method for tackling parthenium infestations (Figure 3). This approach necessitates frequent and consistent efforts, which can be impractical for managing extensive areas. Ideally, this method should be carried out prior to the flowering stage, while the soil is damp. However, it's important to note that this approach is both labor-intensive and costly for effective parthenium control.

Figure 3. Manual removal of *Parthenium hysterophorus*

5.2. Chemical Control of Parthenium hysterophorus

Chemical control has emerged as a preferred approach for managing parthenium due to its speed, cost-effectiveness, and high efficiency in comparison to mechanical methods. This method is widely adopted in numerous countries as it provides rapid and impactful results in curbing parthenium infestations. List of chemicals recommended to control parthenium in cropped and non-cropped areas is presented in Table 2 & 3.

Table 2: Herbicides recommendation for control of Parthenium hysterophorus in non – cropped areas

Herbicides name	Time	Rate (kg/ha)	Stage of application
Diquat	POE	0.5 - 1.0	Rossete stage
2,4-D Na, amine or ester	POE	0.8 - 1.0	-do-
Dicamba	POE	1.6	-do-
Glyphosate	POE	1.0 - 1.2	-do-
Common salt	POE	15-20% (w/v)	-do-
Metribuzin	POE	1.0 - 1.5	-do-
Glufosinate-ammonium	POE	1.0 - 1.2	-do-

Table 3: Herbicides recommendation for control of *Parthenium hysterophorus* in crop fields

Herbicides name	Time	Rate (kg/ha)	Probable crops
Atrazine	PE	1.0 - 1.5	Maize, Sorghum, Pearl millet
Terbutryne	PE	1.0 - 1.5	Maize, Sorghum, Pearl millet
Pendimethalin	PE	1.0 - 1.5	All cereals, Pulses, Oilseeds
Metribuzin	PE	0.5 - 1.0	Soybean, Potato
2,4-D (Na salt, dimethyl amine or diethyl ester)	POE	0.8 - 1.0	Rice, Wheat, Barley

POE - Post-emergence; PE - Pre-emergence

5.3. Biological Control

Biological control involves the utilization of natural enemies such as insects, fungi (myco-herbicide), viruses, and competitive plants to manage weed populations. While this method rarely achieves complete eradication of the target weed, it effectively maintains the biomass and population of the weed below the economic threshold level. What sets biological control apart is its capacity to avoid the need for repeated release or application of natural enemies, with the exception of myco-herbicides. Additionally, bio-agents possess the ability to self-perpetuate and spread independently. This approach proves to be cost-effective and environmentally benign, as it poses no risks to ecosystems, biodiversity, or non-target organisms. The pursuit of parthenium control through biological agents commenced in 1977. While approximately 160 insect species were identified as parthenium feeders in its native range of Mexico, only about 9 displayed potential as bio-agents. Among these, *Zygogramma bicolorata*, a leaf-eating beetle, emerged as a noteworthy bio-control agent. This beetle effectively curtails parthenium weed growth by feeding on its foliage, offering a promising avenue for sustainable weed management.

The yellow-coloured eggs of *Zygogramma bicolorata* are

Figure 4: Life cycle of *Zygogramma bicolorata*

laid on the ventral side of the leaf, hatching within 4-7 days. The subsequent larval stage feeds on the plant for approximately 15 days before pupating in soil at depths below 15 cm. Emerging as adults after 8-12 days, the beetles undergo a full life cycle in 27-32 days. Both larvae and adults exhibit the ability to feed on parthenium leaves. For effective control, around 4-7 lakh adult insects are required per hectare, given the varying weed densities of 40 to 70 plants per square meter. *Zygogramma bicolorata* exhibits a preference for consuming tender terminal growth and auxiliary buds, subsequently targeting leaf blades. This feeding behavior effectively suppresses flower and seed production. However, it's important to note that in India, *Zygogramma bicolorata* also feeds on sunflower. Hence, the release of *Zygogramma bicolorata* in sunflower-growing areas might need to be restricted to non-sunflower growing seasons. Currently, *Zygogramma* has spread across approximately 7 million hectares, encompassing around 20% of the total parthenium infected areas. Efforts by the ICAR- Directorate of Weed Research, Jabalpur have been instrumental in releasing more than 7.5 lakh beetles free of cost. In addition, a significant contribution of 60 lakh beetles has been made through a consultancy program in the Nagpur region. These collective initiatives have proven pivotal in mitigating the parthenium menace across vast swathes of land.

5.4. Biological Control Agents

- *Zygogramma*, the leaf-defoliating beetle
- *Listronotus*, a stem-boring weevil
- *Simcronyx*, a seed-feeding weevil
- *Epiblema*, a stem-galling moth (Fig 4)
- *Bucculatrix*, a leaf-mining moth
- *Carmenta*, a root-boring moth
- Winter rust - *Puccinia abrupta* var. *partheniicola* (Figure 5) and
- Summer rust *Puccinia melampodii* (Figure 6)

Recently a rust pathogen *Puccinnia abrupta var parthenicola* was identified, which is capable of controlling this weed (Figure 5).

5.5. Competitive Plants

Biological Competitors: Parthenium dominance can be

Figure 5: *Parthenium hysterophorus* stem infected by stem-galling moth (*Epiblema* sp)

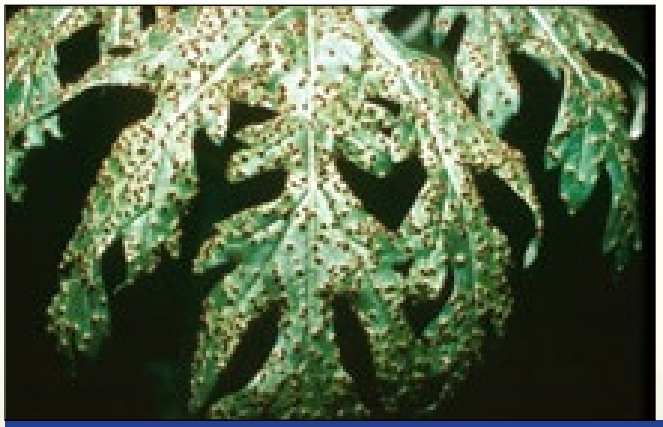


Figure 6: Leaf infection caused by *Puccinia abrupta* var. *partheniicola*

challenged through the strategic planting of competitive species such as *Cassia tora* (Figure 7), *Cassia sericea* (Figure 8), *Croton bonplandianus, Croton sparsiflorus, Amaranthus spinosus, Sida acuta, Tephrosia purpurea, Stylosanthes scabra*, and *Cassia auriculata*. By introducing these species, they actively compete with parthenium, reducing its population and influence. Crop Rotation with Marigold: Employing crop rotation strategies can also prove beneficial. This unique approach disrupts the growth cycle of parthenium, contributing to its management and control. By integrating these techniques into agricultural practices, the persistent threat posed by parthenium can be mitigated while fostering more sustainable and balanced ecosystems.

Cassia seeds were broadcasted during April-May before rains @ 40-50 kg/ha to replace parthenium. Replacement of parthenium by *Cassia tora* in India (Figure 9).

Figure 7: Leaf infected by *Puccinia melampodii*

Figure 7: *Cassia tora* L.

Figure 8: *Cassia sericea* (= *C. uniflora*)

5.6. Management Through Legislation

Legislation aimed at curtailing the spread of parthenium has been enacted in several countries, including Australia. Similarly, efforts were made in the state of Karnataka, India, although their effectiveness remained limited. While enacting laws is a step in the right direction, their impact hinges on the active participation and adherence of the public. However, the success of these initiatives heavily relies on fostering public awareness and garnering community willingness to engage in effective parthenium management practices. Without a collective understanding of the threat posed by parthenium and a shared commitment to its control, even well-intentioned laws may fall short in achieving their intended outcomes. Therefore, combining legislative measures with robust public education campaigns holds the key to addressing the pervasive challenge posed by parthenium.

Figure 9: Replacement of *Parthenium hysterophorus* by *Cassia tora*

6. Alternate Use of *Parthenium hysterophorus*

One promising avenue for managing parthenium

proliferation is its large-scale utilization. parthenium has been extensively studied for its insecticidal, nematicidal, and herbicidal properties, showcasing its potential as a versatile resource. Beyond its conventional classification as a weed, parthenium finds application in various domains. It serves as a valuable source for mulching, contributing to soil health and moisture retention. Additionally, parthenium can be harnessed for producing biogas, paper, and compost. Parthenium compost boasts a nutrient content of 1.05% nitrogen, 0.84% phosphorus, 1.11% potassium, 0.90% calcium, and 0.55% magnesium. The application rates for parthenium compost range from 2.5 to 3 tons per hectare for field crops and 4 to 5 tons per hectare for vegetable crops. The process of compost preparation from parthenium biomass takes approximately 4 to 5 months. A yield of 37-45% compost can be obtained from 4 tons of parthenium biomass. Interestingly, Parthenium as a nutrient bio-resource significantly increased productivity of rice (4.57 t/ha) compared to non-application (4.13 t/ha) and reduced the fertilizer application by 25% (Saravanane et al., 2012). By harnessing parthenium for these valuable applications, its extensive growth can be transformed into a resourceful solution, mitigating its adverse impact and contributing to sustainable agricultural practices.

7. Integrated *Parthenium hysterophorus* Management

Raising Public Awareness: Initiating comprehensive public awareness campaigns is fundamental. Educating communities about parthenium harmful effects and potential solutions fosters a collective responsibility towards its control. In India, Directorate of Weed Research (DWR), ICAR is organizing Parthenium Awareness Week during 16-22 August every year. Till date, it has successfully organized for 18 years. Involvement of Stakeholders: Collaboration among diverse stakeholders, including schools, the general public, civil administration, NGOs, and more, forms a cohesive front against parthenium. Mobilizing various sectors towards a common goal enhances the impact of management efforts. Obnoxious Weed Declaration: Designating parthenium as an obnoxious weed through legislation reinforces the seriousness of its threat. This legal classification underscores the necessity for collective action. Mandatory Removal Notification: Notifying relevant authorities and individuals about the obligatory removal of parthenium is crucial. This step ensures a coordinated effort to tackle its spread. Integration of Methods: Optimal parthenium control demands the synergy of diverse methods. Combining approaches like biological control, chemical control, biological competitors, and crop rotation yields a holistic strategy (Kaur et al., 2014).

8. Conclusion

The management of parthenium demands a comprehensive and integrated approach that encompasses physical, chemical, and biological methods. Raising public awareness about its detrimental impact on plants, animals, and human health is of paramount importance. Adopting a community-based approach for eradication should take precedence in regions where the parthenium problem is particularly severe. By synergizing these strategies, we can effectively combat the menace of parthenium, ensuring healthier ecosystems and safeguarding agricultural sustainability for the future.

9. References

Bashar, H.K., Juraimi, A.S., Ahmad-Hamdani, M.S., Uddin, M.K., Asib, N., Anwar, M.P., Rahaman, F., Haque, M.A. and Hossain, A., 2023. Evaluation of allelopathic effects of Parthenium hysterophorus L. methanolic extracts on some selected plants and weeds. Plos one, 18(1):280159.

Kaur, M., Aggarwal, N.K., Kumar, V. and Dhiman, R., 2014. Effects and management of Parthenium hysterophorus: A weed of global significance. International scholarly research notices, 1-12.

Saravanane, P., Poonguzhalan, R., Chellamuthu, V., 2012. Parthenium (*Parthenium hysterophorus* L.) distribution and its bioresource potential for rice production in Puducherry, India. Pakistan Journal of Weed Science Research 18:551-555.

Saravanane, P., Bajwa, A.A., Djanaguiraman, M., Adkins, S.W, 2023. Biological Response of Invasive Parthenium Weed to Elevated Concentration of Atmospheric Carbon Dioxide and Soil Salinity. Sustainability 15(2):1025.

Tang, S.Q., Wei, F., Zeng, L.Y., 2009. Multiple introductions are responsible for the disjunct distributions of invasive *Parthenium hysterophorus* in China: evidence from nuclear and chloroplast DNA. Weed Research 49, 373–380.

Tamado, T., Ohlander, L., Milberg P., 2002. Interference by the weed *Parthenium hysterophorus* L. with grain sorghum: influence of weed density and duration of competition. International Journal of Pest Management 48(3), 183–188.