A Weed of Global Significance *Parthenium hysterophorus* L.: An Overview of two faces of Parthenium weeds.

Ravikesh Kumar Pal, Durgesh Maurya, Sarvesh Kumar, Raghvendra Singh ,Ambreesh Singh Yadav, and Jitendra Kumar

1, 3-6 Faculty of Agriculture Science and Allied Industries, Rama University, Kanpur-209217

[2]Chandra shekhar Azad University of Agriculture and Technology, Kanpur-209217

***Corresponding Author:** drravikesh.fas@ramauniversity.ac.in

Abstract

The noxious and invasive weed *Parthenium hysterophorus* L., commonly known as "famine weed" or "congress grass," poses significant risks to human health, agriculture, and biodiversity. Renowned for its rapid and aggressive growth, as well as allelopathic characteristics inhibiting the growth of natural vegetation and desirable crops, this abstract provides an overview of both the drawbacks and potential uses of *Parthenium hysterophorus*. Various control methods, including mechanical removal, chemical herbicides, introduction of biological control agents, and cultural practices, are employed to counteract its proliferation. Integrated techniques are often recommended for effective management. Despite its adverse effects, *Parthenium hysterophorus* exhibits some positive attributes. Notably, it possesses therapeutic properties, and ongoing research suggests its potential applications in phytoremediation and biofuel synthesis. Emphasizing the critical need for proper *Parthenium hysterophorus* management, this abstract underscores the importance of comprehensive, long-term solutions to address this environmental menace while exploring its potential benefits.

Keywords: *Parthenium, Ecology and human health Allelopathy, Herbicides, Bioethanol*

Introduction

Parthenium, an annual or short-lived perennial herbaceous weed belonging to the Asteraceae family, poses significant challenges in agricultural and natural settings across multiple countries. Its presence can adversely impact ecosystem health, crop yields, human well-being, and livestock. The term "Parthenium" is derived from the Latin word "parthenice," signifying its historical medicinal associations (Ailey LH 1960). Recognized as "parthenium weed" or "ragweed," this highly invasive and toxic annual herbaceous plant, Parthenium hysterophorus, is a prominent concern. Described as "Congress grass" (Parthenium hysterophorus L.), this tall, extensively branched annual or ephemeral plant belongs to the Asteraceae family, specifically the tribe Heliantheae, contributing to environmental, medicinal, and agricultural issues (Kaur et al. 2014, Pal et al. 2023). Weeds, in general, are plants considered undesirable due to their harmful, hazardous, or economically detrimental characteristics, presenting a substantial threat to both primary production and biodiversity. Parthenium hysterophorus, characterized by a deep taproot, tall stature, branching structure, and an annual (or short-lived perennial) lifecycle, exhibits rapid growth and propagation through seeds (Weyl P. 2022). The wild populations it has established possess the capability for autonomous reproduction, leading to alterations in nearby artificial and natural systems. This prolific

ISSN PRINT 2319 1775 Online 2320 7876

Research Paper © 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

seed producer has allelopathic effects on neighboring plants and competes with economically significant crops. The history of Parthenium hysterophorus is marked by unforeseen consequences, particularly its invasive nature, as observed in the American context (Kaur A et al. 2021). Currently, it has spread to more than 40 countries across five continents, encroaching upon both cultivated and uncultivated areas with diverse climatic, edaphic, and geographic conditions (Adkins and Shabbir 2014). Its relentless invasion of ecosystems, adverse impacts on agriculture, and associated health risks have garnered global attention. The invasive nature of Parthenium hysterophorus is well-established, signifying its expansion beyond its native regions of Mexico, Central America, and South America. Thriving in hot climates, this short-lived, erect plant is known by various names, including carrot weed, star weed, congress grass, wild feverfew, ragweed, caustic weed, white top, and the infamous "Scourge of India" across Asia, Africa, Australia, and the Pacific. Its geographic spread over recent decades poses a significant threat to potential invasions of larger areas worldwide (Connachie 2011 & Patel 2011). This weed is believed to have been introduced to India through US PL 480 grains, commonly known as "Food for Peace," a food assistance initiative by the US government. Its presence in India dates back to the 1950s and has since become a naturalized weed, spreading rapidly across almost every state in the country. Parthenium, also known as Parthenium hysterophorus, has had a substantial impact on India's agricultural landscape, causing a 40% reduction in crop yields (Gitanjali 2009). The cultivation and prevalence of parthenium in India have escalated significantly, encompassing nearly 5 million acres of the country's land (Sankaran 2007). The weed poses a threat to most Indian states, affecting approximately 35 million hectares of both crop and non-crop areas, including roadsides, wastelands, gardens, and railway lines (Singh et al. 2023). In addition to invading communal spaces, roadsides, railway tracks, and forests, parthenium has become one of the most pervasive weeds in various types of agricultural fields. Every state in India has reported varying degrees of Parthenium hysterophorus spread, presenting a significant challenge across the nation, including states like Karnataka, Andhra Pradesh, Haryana, Bihar, Madhya Pradesh, and Uttar Pradesh (Kumar 2014).

Certain states in India exhibit higher densities and widespread distribution of parthenium, such as Andhra Pradesh, Maharashtra, Bihar, Punjab, Chhattisgarh, Delhi, Haryana, Karnataka, Madhya Pradesh, Tamil Nadu, and Uttar Pradesh. States like Jharkhand, Assam, Gujarat, Rajasthan, Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Orissa, and West Bengal experience medium levels of infestation, while the Andaman Islands show low levels. However, the extent of parthenium's infestation varies both across and within states.

Table 1: Status of *Partheniumhysterophorus* in different states of India.

Name of states	**Over all spread and infestation level**
Andaman & Nicobar Islands, Arunachal Pradesh, Goa, Gujarat, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim	Low
Assam, Chandigarh, Chattishgarh, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Orissa, Pondicherry, Rajasthan, Uttarakhand	Medium
Andhra Pradesh, Bihar, Delhi, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Tamil Nadu, Uttar Pradesh	High

Originally, this plant species coexisted benignly with other flora in its native habitat. However, the process of globalization, facilitated by the movement of people, goods, and agricultural products, enabled this seemingly harmless weed to traverse continents and establish itself as a formidable invasive species. Parthenium rapidly spreads through wind-dispersed seeds, presenting significant challenges for control. Management strategies encompass manual removal, herbicides, and biological controls using insects. A comprehensive understanding of Parthenium hysterophorus' effects, habitat, and biology is crucial for effective control and management of this hazardous weed. This review aims to explore the multifaceted issues surrounding Parthenium hysterophorus, delving into its taxonomy, morphology, distribution, spread, ecological implications, agricultural impact, and health hazards for both humans and livestock. Additionally, the paper will examine various control and management strategies employed to counteract Parthenium's proliferation, addressing challenges and considering future prospects for control. Emphasizing the importance of ecological restoration efforts, the review evaluates legislative and regulatory measures in place to mitigate the global spread of this invasive weed. By addressing these issues, the review seeks to raise awareness about the severity of the Parthenium problem, underscoring the need for ongoing research and coordinated action to mitigate its adverse effects on the environment, agriculture, and public health.

Taxonomy and Morphology

Parthenium hysterophorus, commonly referred to as "famine weed" or "congress grass," is a member of the Asteraceae plant family. While the Parthenium genus encompasses several species, P. hysterophorus stands out as the most widely acknowledged and problematic. Taxonomically, it is classified as follows: [USDA 2010]

- **Kingdom:** Plantae
- **Phylum:** Angiosperms
- **Class:**Dicotyledonous plants
- **Order:** Asterales
- **Family:** Asteraceae
- **Genus:***Parthenium*
- **Species:***P. hysterophorus*

The Parthenium genus consists of 17 species, originating from tropical America, with one species, Parthenium argentatum Gray (Guayule), holding potential economic value. Other weedy genera in the Ambrosiinae subtribe include Xanthium, Ambrosia, Iva, Hymenoclea, Dicoria, Parthenice, and Euphrosyne, all native to the Americas. Crop plants of economic significance in the Heliantheae tribe include sunflower (Helianthus annus L.), Jerusalem artichoke (Helianthus tuberosus L.), and niger seed (Guizotia abyssinica Cass.). This categorization places Parthenium hysterophorus in the broader group of asters, daisies, and sunflowers, establishing it as a distant relative of well-known garden flowers. Parthenium hysterophorus is a densely branched, annual, upright herbaceous plant that forms rosettes early in its growth and can reach a height of 2.5 meters or more in maturity (Navie et al. 1996). Each flower-head contains seeds, known as achenes, composed of two straw-colored papery structures (dead tubular florets) and a flat bract. The seeds are obovate to ellipsoid, light brown when young, and dark brown when mature (Kohli et al. 1994). Parthenium flowers 24-48 days after germination, occurring throughout the year. Optimal weed seed germination takes place at alternating temperatures of 21/16°C (day/night). Seeds can survive in the soil as a seed bank for 4-6 years, with submerged seeds demonstrating longer viability compared to soil-surface seeds (Patel 2011). The stem is cylindrical, solid, fluted, with longitudinal lines matching leaf midribs, and mature stems are greenish with tiny soft hairs. Leaves are alternately arranged and stalked (petioles) up to 2 cm long, with two types—early rosette leaves and alternate, simple, deeply pinnatifid leaves. Lower leaves have broad, sharply split blades (10–20 cm long and 6–10 cm wide) with short, stiff hairs on the abaxial surfaces (Vélez et al. 2019). Terminal panicles consist of clusters of capitulum (small flower heads), each supported by a stalk. Capitulums (3-5 mm broad) are off-white or white with 0.3-1 mm ray florets, and they contain 15-60 tubular florets in the center, encircled by two rows of tiny green bracts. Flowers can appear year-round, with a higher frequency during the rainy season.

1. **Seed dispersal: Parthenium hysterophorus** primarily spreads through seed dispersal, exhibiting a prolific capability to produce 154,000 seeds/m2 and an average of 15,000–25,000 seeds per plant. These seeds, being lightweight, are easily transported by various means, including wind, water, machinery, livestock, feral and native animals, as well as through feed and seeds. Drought conditions further facilitate seed dispersion, especially due to increased stock fodder and travel (Singh et al. 2023). Parthenium possesses the ability to regrow from fragmented portions, and its rapid proliferation in India is attributed to allelopathic effects and the absence of natural enemies, such as insects and diseases. The seeds of Parthenium can germinate within a temperature range of 8º to 30º C, with the optimal range being 22º to 25º C. Persistence studies reveal that seeds buried 5 cm below the soil's surface maintain a survival rate of over 70% for at least two years, while seeds on the soil's surface last only for six months (Sankaran 2007). Furthermore, there is documented evidence of 20-year seed viability.
2. **Causes of rapid spread of *parthenium***
   - **2.1.High reproductive capacity**: The Parthenium weed is known for its prolific seed production, with the capability of yielding up to 25,000 seeds per plant [Navie et al 2003]. Furthermore, it maintains an extensive seed bank, estimated at 200,000 seeds/m2 in abandoned fields [Joshi 1991]. Parthenium seeds exhibit the ability to germinate throughout the year, given sufficient moisture levels, and can adapt to highly unfavorable environmental conditions.
   - **2.2.Rapid growth rate:** The Parthenium weed displays a swift growth pattern. Typically, plants commence flowering within 4 to 8 weeks of germination, and this flowering phase may persist for several months. Under unfavorable conditions, such as drought stress, the weed can complete the entire lifecycle—from sprouting, growth, maturation to seed setting—in as little as four weeks.
   - **2.3.Allelopathic potential:** Parthenium exhibits allelopathy, a phenomenon wherein it inhibits the germination and growth of other plants. Studies indicate that water-based extracts from Parthenium leaves and flowers hindered the germination and growth of barley, wheat, and peas. Furthermore, when Parthenium extracts were directly sprayed on food plants, it resulted in a significant reduction in cell survival and chlorophyll content [Kumari et al. 2014].
   - **2.4.Unpalatable to animals:** Research has revealed that goats can consume Parthenium, while buffalos, cows, and sheep find it unpalatable. Previous findings in India highlight significant health risks to cattle in areas invaded by Parthenium [Javaid 2005]. Artificial feeding studies showed that cattle, bulls, and buffalo accepted the weed either alone or in combination with

ISSN PRINT 2319 1775 Online 2320 7876
Research Paper © 2012 IJFANS. All Rights Reserved, UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

green feed, leading to severe dermatitis and toxic symptoms in most cases, with fatalities occurring within 8 to 30 days.

4. Infestation of *Parthenium hysterophorus*

4.1.Agriculture: In the period preceding 1980, this weed was seldom encountered in cultivated lands; however, it now permeates virtually all agricultural crops, forests, and plantation environments. Parthenium has emerged as a detrimental agricultural weed in various regions such as Uttar Pradesh, Uttarakhand, Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, among others. It flourishes during fallow intervals following moderate rainfall in areas with single-crop agriculture, exhibiting particularly robust infestations in irrigation canal fields. The Parthenium hysterophorus weed prospers in confined, human-engineered water systems like ditches or canals, owing to the presence of moisture and irrigation water canal seeds.

4.2.Woodlands: Previously absent in gardens and wooded areas, this plant has rapidly proliferated, particularly thriving in orchards due to inadequate weeding. The Parthenium weed poses challenges to mango orchards in Uttar Pradesh, Madhya Pradesh, and Maharashtra, causing concerns for producers. In Himachal Pradesh, most lower-elevation apple orchards are also affected by this weed. Orange plantations in Maharashtra are grappling with Parthenium weed issues. Flourishing in barren lands, wastelands, and woodlands, it impedes the growth of other plants, posing a threat to local biodiversity. Indian National Parks, including Pench, Rajaji, Kanha, and Bandhavgarh, have also fallen victim to the invasion of Parthenium weed.

4.3. Barren Lands: Parthenium hysterophorus finds its ideal habitat in bare soil, thriving on roadsides, around industries and mills, platforms, and even in areas unsuitable for agricultural cultivation due to metal toxicity or mineral nutrient deficiencies. A notable characteristic of Parthenium weed is its adaptability to diverse environments and its capacity to endure harsh conditions that challenge other plant species. This adaptability contributes significantly to the rapid spread of Parthenium as an invasive weed in India and other countries.

5. Harmful Effects of *Parthenium*

5.1. Impact on Human Health: A significant proportion, approximately 73%, of individuals residing in areas with parthenium weed exhibit sensitivity to its components, with females being twice as susceptible as males (Javaid, 2005). Agricultural laborers are particularly at risk, facing potential harm from prolonged exposure during farming activities, leading to allergic reactions and issues related to the skin and respiratory system. P. hysterophorus has been linked to various cutaneous and respiratory diseases in humans (Ashebir et al., 2012). Airborne contact dermatitis (ABCD) is a notable consequence affecting facial areas, eyelids, neck, chest, and popliteal fossae. Chronic actinic dermatitis (CAD) manifests on the forehead, cheeks, nape of the neck, rim of the ears, forearms, hands, under the chin, and skin folds (Tamado et al., 2002). Other skin abnormalities include mixed patterns of ABCD and CAD, with scattered infiltrating scaly papules over exposed areas, eyelid dermatitis, and neck extremity flexures. A distinct photosensitive lichenoid eruption pattern results in violaceous papules and plaques on sun-exposed areas such as cheeks, forehead, ears, upper chest, back, and hand dorsae (Kaur et al., 2014). Multiple hyperkeratotic papules and nodules, displaying

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

prurigo nodularis-like histopathology, are also observed (Kaur et al., 2014 & Sharma et al., 2013). The initial symptoms include fever and respiratory issues, progressing to the development of asthma and allergic bronchitis after 3–5 years of incremental exposure (Ayele, 2007).

5.2.Impact on Animal Health: Plants like Parthenium hysterophorus can pose threats to animals, leading to a condition known as "parthenium poisoning" in livestock. This results in the manifestation of symptoms related to the skin, respiratory system, and digestion. Studies have shown a significant decrease in the white blood cell count of rats, indicating that parthenium extract can weaken the immune system (Yadav et al., 2010). Pastures contaminated with parthenium can induce weight loss and even death in livestock, with the herb capable of causing fatalities in cattle ranging from 10% to 50% of their diet. The invasive nature of this plant can also diminish the quality and quantity of forage in pastures and rangelands, impacting the health and productivity of grazing animals. Continuous consumption of Parthenium hysterophorus for up to 12 weeks has been linked to the development of dermatitis and anorexia in mature livestock (Osmanabadi) (Khaket et al., 2015). Furthermore, acute diseases can arise when bitter milk and infected buffalo, cow, and goat meat are consumed from animals that have ingested parthenium-laced grass. The elimination of parthenium weed is crucial for safeguarding the health of domestic and wild animals in affected areas.

5.3.Impact on Ecosystem: Parthenium hysterophorus, commonly known as parthenium weed, poses significant harm to ecosystems. Functioning as a highly aggressive invasive species, it displaces indigenous plants, resulting in a decline in biodiversity. In the Mehari Sub-Watershed of the Rajouri Forest Range in India, the invasion of Parthenium weed into new areas leads to the replacement of native plants, causing a loss of biodiversity (Kumar et al., 2013). This disruption of the ecological balance can adversely affect various organisms that rely on native flora for habitat and sustenance. The introduction of Parthenium weed into Awash National Park in Ethiopia resulted in a substantial 69% reduction in the stand density of herbaceous species within a few years (Javaid A and Adrees H., 2009). With its aggressive colonization of areas such as wastes, roads, railways, water courses, cultivated fields, and overgrazed pastures, Parthenium weed expanded its invasion to cover 14.25 million hectares of farmland during 2001-2007, a significant increase from 2 million hectares in 1991-2000. This invasive weed alters soil chemistry and depletes water resources, contributing to a reduction in crop production by competing for nutrients and space. The removal of Parthenium weed is imperative for maintaining ecosystem health, mitigating its adverse impact on native plant and animal species, soil quality, and water systems.

5.4.Impact of Parthenium on crop production: Parthenium hysterophorus, commonly known as parthenium weed or Congress grass, has a detrimental impact on crop production. This invasive plant competes with crops for essential resources such as water, nutrients, and sunlight, leading to a reduction in crop yield. The leaf litter of Parthenium weed can impede seedling emergence and adversely affect the early growth of various pasture and crop species (Kanchan & Chandra, 1980). Soil pollution is another consequence, as the leaves of Parthenium weed produce p-coumaric acid and caffeic acid, hindering the germination,

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

growth, and yield of traditional Indian crops (Ashebir et al., 2012). The rapid growth and allelopathic properties of Parthenium weed can further inhibit the germination and growth of crops. Research suggests that Parthenium weed is more prevalent in corners of wheat fields, resulting in a 2 to 3% decrease in production. Its allelopathic effects pose challenges for the germination and growth of wheat, rice, maize, pigeon pea, sorghum, tomatoes, brinjal, beans, cereals, and black gram, leading to a significant reduction in yields by up to 40% (Dukpa et al., 2020). Moreover, the prolific pollen of Parthenium weed can cause allergic reactions in field workers, disrupting agricultural activities. The presence of Parthenium weed in harvested crops can also lead to contamination, making the produce less desirable for sale or consumption. Effective management and control measures are imperative to mitigate the adverse effects of Parthenium weed on crop production.

5.5.**Impact on Soil:** Parthenium hysterophorus, commonly known as parthenium weed, exerts negative effects on soil. This invasive plant can modify soil chemistry through the release of allelopathic compounds, inhibiting the germination and growth of native plants. By competing with other vegetation for essential nutrients and water, Parthenium weed depletes soil resources, leading to a reduction in soil fertility. Parthenium hysterophorus L. demonstrated inhibitory effects on Rhizobium phaseoli and Azotobacter vinelandii, along with the suppression of crucial weed inhibitors such as parthenin, caffeic acid, and anisic acid (Timsina et al., 2011). Invaded plots exhibited elevated pH, phosphate, and potassium levels, while non-invaded plots showed low to moderate values (Etana et al., 2015). Parthenium weed has the ability to absorb nutrients from nutrient-depleted soils, resulting in increased nitrogen (3%), phosphorus (2%), potassium (4%), and other nutrients, making it a potential green manure for field crops (Shi et al., 2021). Additionally, the decomposition of parthenium weed can lead to soil acidification, further hindering the growth of desired crops and plants. In soils with parthenium weed leaf litter, all tested plant species experienced 20–40% lower seedling emergence. The leaf litter from one to two parthenium weed plants may inhibit seedling emergence from other plant species in the seed bank (Ayana et al., 2015). The accumulation of parthenium biomass can impede water infiltration and exacerbate soil erosion. While some studies suggest that most soil parameters in infested quadrats are better than non-infested ones, emphasizing a potential lack of adverse impact on soil nutrients (Batish et al., 2002), it is crucial to note that Parthenium residue extracts were found to be phytotoxic to test crops and rich in phenolics. This phytotoxicity affects the growth of radish and chickpea and has implications for associated soil chemistry (Girish, 2020). These soil-related impacts underscore the importance of controlling and managing parthenium weed to maintain healthy and productive soils.

6. Management of *Partheniumhysterophorus*

Due to its rapid reproductive rate, the parthenium weed poses a formidable challenge in eradication efforts. The urgency to address this issue stems not only from its environmental impact but also its significant threat to public health. With India facing the potential widespread invasion of the weed across its agricultural fields (Bhateria et al., 2015), immediate measures are crucial to curb its spread. In response to this threat, extensive research is underway to identify the most effective and

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

economical methods for prevention, with a focus on practical and affordable strategies for eradication (Dheer et al., 2023). Various control mechanisms are being explored for implementation in India, including: proceed with listing the control mechanisms.

6.1.Mechanical: The most effective approach involves the manual removal of parthenium before it reaches the flowering and seed-setting stage, as suggested by Bhateria et al. (2015). This task is simpler when the soil is moist, and its success hinges on avoiding the growth of the infestation that occurs if the weed is pulled after seed setting. Some landholders have found success in ploughing parthenium weed during the rosette stage, but this must be followed by direct seeding of perennial grassland or the planting of a crop (Sankaran et al., 2007). It is crucial to note that pulling a flowering plant disperses pollen grains, triggering allergy responses. To mitigate this, sowing pastures or alternative plants and ploughing the weeds before flowering may be helpful. However, precautions such as wearing hand gloves and nasal masks are essential, and this method is considered a short-term solution that requires repetition (Dhiman et al., 2014). In instances of early signs of bolting or flowering, hand weeding should be promptly carried out. Delaying weed removal may not prevent seed production, especially if the uprooted plants are left in the field. Nevertheless, it's important to acknowledge that in large regions with high infestation, the manual technique may not be cost-effective or feasible (Sankaran et al., 2007).

6.2.Cultural: Plant canopies with competitive characteristics can effectively hinder the growth and reproduction of parthenium weeds, as indicated by Singh et al. (2023). To prevent weed development during the cropping season, farmers can employ specific cropping techniques that promote rapid crop growth and establishment. One strategy involves planting fast-growing crops like sorghum, berseem, and dhaincha/sesbania (O'Donnell, 2005). Researchers also suggest cultivating competitive crops such as Digitaria milanjiana, Clitoria ternatea, and Cenchrus ciliaris to reduce the prevalence of Parthenium (Anonymous, 2010). Another approach is to introduce plants that compete with parthenium, thereby diminishing its population. Species like Cassia sericea, Croton bonplandianus, C. sparsiflorus, Amaranthus spinosus, Sida acuta, Tephrosia purpurea, Stylosanthes scabra, and Cassia auriculata are recommended for this competitive replacement strategy (Sankaran, 2009). Cassia tora can be planted to cover and inhibit the growth of parthenium in a similar manner. The spread of parthenium can be significantly minimized by addressing potential carriers, including vehicles, animals, and agricultural products. Taking preventive measures, such as cleaning vehicles and equipment before entering non-affected areas, can reduce the risk of seed dispersal (Fisheries, 2023). Ultimately, the most cost-effective approach is to proactively prevent the spread of parthenium.

6.3.Control by burning: 6.3. Control through Burning: The predominant method employed for managing parthenium weed involves burning, facilitating the efficient eradication of substantial amounts of its vegetation. However, this approach poses significant risks as it greatly threatens soil water, fertility, and biodiversity. Despite the allelopathic effects of parthenium ash on certain plants, the yield loss is relatively minimal when compared to the dry mass of the weed (Bhateria and Snehlata, 2015). Burning, as a method of parthenium

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

control, is not highly effective. Nonetheless, if the burned area is allowed time to recover before further actions are taken, burning for other purposes (such as controlling woody weeds) may not exacerbate the infestation (Mahadevappa & Patil, 1997). It's important to note that stocking recently burned areas where parthenium is known or suspected to be present can reduce pasture competition and favor parthenium, potentially leading to a more severe infestation (Nigatu et al., 2010).

6.4.Overgrazing control: The most effective way to manage large-scale *parthenium* infestations is through grazing management. Keep pastures well-maintained with high ground and grass crown cover levels. [Nigatu et al., 2010]. On the other hand, *parthenium* has a relative rise in some areas due to overgrazing. Because of the significant rise in livestock, overgrazing reduces the vitality and variety of grasslands, which encourages the weed to spread even more widely. Therefore, maintaining the proper amount of cattle might stop *Parthenium* from spreading. [Inderjit 2003] Cattle movement during rainy season helps disseminate seeds on muddy soil. To allow seeds fall off cow bodies and tails before releasing them into bigger regions, hold them in yards or small paddocks if necessary. Check for *Parthenium* contamination while buying livestock feed and agricultural seeds. Spring-summer is ideal for pasture sapling, especially the first 6-8 weeks. Winter grazing is safe since *Parthenium* spreads less. This is also when *Parthenium* may develop and germinate.

6.5.Allelopathic control: The ecological approach of allelopathy and the utilization of allelochemicals as a biological herbicide have presented a challenge to existing control methods, as noted by Javaid et al. (2005). Recent investigations, including studies conducted by Anjum et al. (2005) and Wahab (2005), have shown highly favorable results in using allelopathic plants for parthenium control. The biological control of parthenium is facilitated by the cultivation of competitive crops such as fodder sorghum, sunflower, and maize, or the introduction of self-perpetuating competitive plant species like Abutilon indicum in non-crop areas. A botanical survey in India identified several plants, including Cassia sericea, Cassia tora, Cassia auriculata, Croton bonplandianum, Amaranthus spinosus, Tephrosia purpurea, Hyptis suaveolens, Sida spinosa, and Mirabilis jalapa, which exhibited the ability to suppress parthenium in natural habitats (Javaid A & Anjum T., 2006). Additionally, research conducted in India demonstrated that Cassia sericea reduced parthenium accumulation by 70% and the population by 52.5% (Gnanavel, 2013). In certain regions of India, crop rotation with marigold (Tagetes spp.) during the rainy season has been found to reduce parthenium infection in cultivated areas (Kaur et al., 2014).

A) Chemical Control: The use of chemical methods for controlling parthenium weed is on the rise in India (Kaur et al., 2014). In areas lacking natural adversaries, chemical management has proven effective for parthenium control (Sankaran, 2007). Herbicides stand out as the most efficient and widely employed means of managing parthenium weed (Dheer and Yadav, 2021; Singh et al., 2023). The timing of chemical treatment is crucial for this strategy, emphasizing the need to address the weed before blooming and seed setting, allowing other plants to recolonize the affected area. In non-cropped areas such as wastelands, railway lines, water canals, and roadsides, post-emergent herbicides are recommended during the rosette stage (Singh et al., 2005). While modest quantities of natural and biological herbicides, such as oils derived from medicinal plants, can be useful in controlling parthenium, conventional herbicides currently prove more successful than bioherbicides.

B) Non-Crop Area: In non-crop areas, herbicides should be applied before seeding, with immediate treatment for small infestations. Repeated spraying is advised to prevent seeding, and tiny plants should be sprayed before blossoming. The active growth of other grasses may aid in suppressing the weed. Chemical herbicides like glycerophosphate, bromoxynil, NaCl, amine esters, fluometuron, hexazinone, metribuzin, atrazine, norflurazon, metasulfuron methyl, and paraquat have demonstrated effectiveness in controlling parthenium (Singh et al., 2005). While chemical pesticides can effectively manage this weed in both agricultural and non-cropping regions, it is essential to note that these herbicides may cause harm to main crops, posing risks in cropping regions. Different herbicide dosages can be applied through spot spray, boom spray, or a combination of both.

C) Cropping areas: In cropping areas, the use of chemical herbicides, while deemed safe in non-farming regions, requires caution as it can potentially harm crop plants. The application of chemical fertilizers in agriculture necessitates a judicious selection of herbicides to prevent damage to crops. In such agricultural regions, the use of low-concentration biological or natural pesticides, such as volatile oils derived from aromatic plants, can be beneficial in preventing the development of Parthenium seeds. The impact of these oils on modern crops is minimal or nonexistent when compared to their effect on Parthenium. Importantly, these essential oils do not have any adverse effects on existing vegetation or crops (Ray & Gour, 2014). Numerous observations have indicated that essential oils from various plants, including Ageratum, Lantana camara, and Eucalyptus sp., can be effective in controlling parthenium.

6.6 **Biological Control:** Biological control, employing natural enemies, emerges as a secure, effective, and environmentally friendly method to reduce or mitigate the impact of pests. Over the past three to four decades, considerable attention has been devoted to controlling Parthenium using various biocontrol agents, including insects, microbial diseases, and botanicals (Sayed, 2005). Two primary approaches are employed in biological weed control: the "classical approach," which entails introducing foreign pathogenic organisms, and the "augmentative" or "bioherbicidal approach," which involves introducing or mass-raising native pathogenic organisms already present to boost their population. In epidemiological terms, these strategies are known as "inoculative" and "inundative strategies" (Aneja, 2009). The use of plant pathogens for the biological management of weeds has become commonplace in agroecosystems, representing a safe, effective, and ecologically friendly approach to weed control (Kanagwa et al., 2020).

A) Classical approach: Several countries have successfully employed insects as a means to control parthenium weed. Leaf-feeding beetles, specifically the Mexican-imported Zygogramma bicolorata, and stem-galling moths, such as Epiblema strenuana, have shown efficacy in suppressing this plant. The introduction of the Z. bicolorata beetle from Mexico to Australia in 1980 aimed at controlling parthenium weed has proven successful. In India, Z. bicolorata was introduced in 1984, and within three years, it had widespread distribution, significantly reducing Parthenium weed densities in certain areas (Dhileepan, 2001). Both the larvae and adults of this insect feed on the leaves. Early-stage larvae target terminal and auxiliary buds before moving to leaf blades, and adult larvae pupate in the soil. Despite the weed's strong generative capacity, this insect is not species-specific and has been observed attacking sunflowers in India. Leaf skeletonization can occur with an insect density of one adult per plant after 4–8 weeks (Shabbir et al., 2016). Limited trials have been conducted on biological control agents like Z. bicolorata against this invasion. In Tanzania, the Tropical Pesticides Research Institute released Z. bicolorata beetles as bio-agents to inhibit P. hysterophorus between February and July 2019 (wet season) and August 2019 to January 2020 (dry season). The feeding activity of Z. bicolorata led to a reduction in Parthenium leaves, flowers, height, and biomass during both dry and rainy seasons. Consequently, Zygogramma bicolorata proves to be a valuable biocontrol agent that can significantly impede the vegetative and reproductive development of Parthenium weed. However, attempts to introduce the stem-galling moth Epiblema strenuana were hindered, as it grows on niger crops and deposits eggs there, resulting in the destruction of its cultures. Many nations have used insects to manage *parthenium* weed. Mexican-imported leaf-feeding beetles (Zygogrammabicolorata) and stem galling moths (Epiblemastrenuana) can suppress this plant. The leaf-eating Z. bicolorata beetle was brought from Mexico in 1980 to control *parthenium* in Australia. Zygogrammabicolorata was originally brought to India in 1984, and three years after its introduction, it had spread widely over the country, significantly reducing the densities of *Parthenium* weed in certain locations.[Dhileepan 2001].This insect's larvae and adults eat leaves. The early-stage larvae eat terminal and auxiliary buds before moving to leaf blades. Adult larvae pupate on dirt. The weed has strong generative capacity and the insect is not species-specific, attacking sunflower in India. An insect density of one adult per plant produced leaf skeletonization after 4–8 weeks [Shabbir et al. 2016]. Few trials on biological control agents like Zygogramma bicolorata against this invasion exist. The Tropical Pesticides Research Institute in Arusha, Tanzania, released Z. bicolorata beetles as bio-agent to inhibit P. *hysterophorus* from February to July 2019 (wet) and August 2019 to January 2020 (dry). Z. bicolorata feeding reduced P. *hysterophorus* leaves, flowers, height, and biomass in dry and rainy seasons. Thus, Zygogramma bicolorata is a useful biocontrol agent that may considerably slow down *Parthenium* weed's vegetative and reproductive development. The stem galling moth Epiblema strenuana has also been attempted to be introduced, however because it grows on niger crops and deposits its eggs there, its cultures were destroyed.

B) **Bioherbicidal approach:** Plant pathogenic fungi are employed as "living products that control specific weeds in agriculture as effectively as chemicals" or inundatively for weed control. Bioherbicides involve the regular distribution of varying quantities of pathogenic inoculum. The concept of mycoherbicides was introduced by Daniel and colleagues (Aneja, 2009), demonstrating how an endemic illness can be eradicated in its weedy host by administering a high dose of inoculum during a critical developmental stage. For a mycoherbicide to be effective, certain criteria must be met. The pathogen needs to be culturable in artificial media, and the inoculum should be produced in large quantities using traditional techniques like liquid fermentation. The finished product must be genetically stable and specific to the target weed, and handling, application, and storage should align with modern agricultural practices. Additionally, the pathogen should be effective in various environmental conditions to allow for reproduction. Fungal products or mycoherbicides have been successfully utilized to control weeds (Gajendran, 1982). Plant pathogenic fungi are used as "living products that control specific weeds in agriculture as effectively as chemicals" or inundatively to control weeds. Bioherbicides are given by regularly distributing varying quantities of pathogenic inoculum. The notion of mycoherbicides was first presented by Daniel and colleagues. [Aneja 2009], who demonstrated how an endemic illness may be eradicated in its weedy host by administering a high dose of inoculum during a critical developmental stage. The pathogen needs to be culturable in artificial media, the inoculum needs to produce in large quantities using traditional techniques like liquid fermentation, the finished product needs to be genetically stable and specific to the target weed, handling, application, and storage needs to be in line with modern agricultural practises, and the pathogen needs to be effective in a variety of environmental conditions in order to allow for reproduction. Weeds have been controlled with fungal products or mycoherbicides [Gajendran 1982].

6.6.Integrated Weed Management: This plant has proven resistant to both classical and bioherbicidal treatments. In an effort to minimize insect losses, reduce the reliance on chemical pest control, and safeguard agricultural systems, integrated pest management (IPM) has gained popularity. In Australia, Mitchell grass (Astrebellasqurossa) and butterfly pea (Clitoriaternatea) have been utilized, along with two biological control agents—a leaf and seed-feeding beetle (Zygogrammabicolorata) and a stem-galling moth (Epiblemastrenuana)—as part of integrated weed management to control parthenium weed. The inclusion of suppressive plants has significantly decreased weed growth even without biological control, and the use of biological substances has demonstrated the potential to enhance suppressive power. Research conducted in Australia, as outlined by Sankaran (2007), indicates that suppressive plants played a crucial role in controlling parthenium weeds for two years. The presence of Epiblemastrenuana Walker, Zygogrammabicolorata Pallister, Listronotussetosipennis Hustache, and Pucciniaabrupta var. partheniicola resulted in a 60–80% reduction in parthenium weed growth in the first year and a 47–91% reduction in the second year. Additionally, biocontrol agents contributed to a 6%–23% increase in suppressive plant biomass. The combination of biological control agents with strategically planted suppressive plant species has proven effective in controlling parthenium weed. Furthermore, the use of rice straw has been identified as an effective approach for controlling parthenium weed in standing wheat crops (Singh et al., 2023).

7. Utilization of *Parthenium*

Despite being a weed, *Partheniumhysterophorus* offers a lot of advantages. The plant has several industrial, pharmacological, and therapeutic uses in addition to a wide range of other uses. As a result, the plant may be utilised directly for a variety of uses, and it can be widely employed in a variety of ways to manage this weed. Utilising this weed on a wide scale is one of the best ways to handle *partheniums*. The weed's insecticidal [Bala et al. 1986], nematicidal [Pandey et al. 1993], and herbicidal [Gunaseelan 1987] qualities have all been well studied. Here, we've covered *Partheniumhysterophorus's* documented uses, which can be applied to manage it through utilisation. Additionally, this weed is used to produce biogas and oxalic acid [Ambasta and Kumari 2013]. One way to handle *parthenium* is to use it as green manure. Even in soils with low nutrient levels, it may

ISSN PRINT 2319 1775 Online 2320 7876
Research Paper , UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

extract nutrients. Because of the insecticidal, nematicidal, and herbicidal qualities of this unpleasant weed extract, numerous scientists and academics have begun to use it [Kumar et al 2013]. Below is a quick description of a few of this weed's significant uses:

7.1 Biochar Preparation: Biochar has been successfully produced by pyrolyzing Parthenium hysterophorus, providing a means to store carbon and achieve zero carbon dioxide emissions (Patel, 2011). The addition of this biochar to the soil demonstrated positive effects, including increased growth of Zea mays, enhanced basal respiration, microbial biomass carbon, catalase and dehydrogenase activities, reduced soil stress, and heightened hydrolytic enzyme activity. The charring process at high temperatures also led to the degradation of Ambrosin, a phototoxic molecule found in parthenium (Gul et al., 2023). Notably, substantial additions of biochar did not exhibit any adverse effects on the soil. The study suggests that incorporating biochar can benefit barley under drought stress by enhancing antioxidant defense mechanisms, productivity, and soil fertility. Consequently, utilizing biochar derived from the invasive plant P. hysterophorus could be employed to boost barley crop output in water-deficient regions.

7.2 Biogas Production: The invasive weed Parthenium hysterophorus, abundant in India, was utilized for biogas production. In 3-liter batch digesters, parthenium was mixed with cattle faeces at a 10% concentration and allowed to undergo anaerobic processing at room temperature. The resulting biogas showed methane percentages ranging from 60% to 70%, and the degradation of phytotoxic allelochemicals was observed during the biogas formation (Hailu & Chimdessa, 2020). Experimental data indicated that a mixture of 75% goat manure and 25% parthenium weed yielded the highest gas output of 572.5 milliliters, suggesting its suitability for optimal biogas production. Co-digesting goat manure and parthenium weed demonstrated significant enhancements in biogas generation and reductions in volatile solids and total solids (TolikaSwu et al., 2022).

7.3 Composting: Composting Parthenium offers a sustainable method to convert this weed into a valuable soil conditioner (Murthy et al., 2010). Parthenium compost, rich in micronutrients such as Fe, Zn, Mn, and Cu, as well as macronutrients like NPK, has been found to be two times richer than farmyard manure. The composting process liberates insoluble K and improves P and K absorption through organic acids (Ameta et al., 2016). Parthenium compost contains enzymes, vitamins, antibiotics, plant growth regulators, Azotobacter, and phosphate solubilizers (Chitale et al., 2020). Comparisons with other organic wastes highlight Parthenium's composting usefulness in adding nutrients to crops. Turning Parthenium into compost through methods like NADEP AC and Bangalore pit BC enhances nutrient concentrations for crop cultivation, providing a more sustainable approach than burning or eliminating the weed (Vyankatrao, 2017; Hussain et al., 2016).

7.4 Vermicomposting: Vermicompost, produced exclusively by the epigeic earthworm Eisenia foetida using parthenium (Parthenium hysterophorus), was examined for its impact on the germination and early growth of green gram (Vigna radiata), ladies' finger (Abelmoschus esculentus), and cucumber (Cucumis sativus) [Singh and Kumar, 2018]. The fertility-related physicochemical parameters were assessed in all treatments, revealing a decrease in pH, conductivity, and total organic carbon over 90 days, while concentrations of nitrogen, potassium, sodium, and phosphorus increased. Both Parthenium and cow faeces were found to be suitable for vermicomposting [Sharma et al., 2016]. Vermicomposting methods, including pit and worm bin vermicomposting, were employed, and the nutrient content (N,

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

P, K, Ca, and C:N ratio) was monitored at 20-day intervals for up to 100 days. Worm bin vermicompost (BVC) demonstrated higher nutrient content compared to PVC, AC, and BC composts. This approach transforms the invasive Parthenium into nutrient-rich vermicompost suitable for crop cultivation [Sharma et al., 2023]. In an experiment, Parthenium vermicomposts significantly enhanced soybean vegetative growth in various seasons, outperforming control groups [Singh and Kumar, 2018].

7.5 Green Manure: Parthenium hysterophorus, known as "wild carrot weed," is a notorious invasive plant with rapid growth and environmental damage. While it may offer biomass for green manure, its invasive nature makes it unsuitable. To avoid ecological harm, it is recommended to utilize non-invasive plant species for green manure. Managing this weed involves using it as compost, green manure, or mulch to enhance soil health and crop productivity. Incorporating Parthenium biomass into crops sequentially can enhance crop productivity by improving plant nutrient availability, soil health, and overall plant well-being [Chamle et al., 2014]. In an experiment in Aurangabad, the application of Parthenium foliage as green manure increased maize output and nutrient content, potentially mitigating the negative impact of this weed on agriculture and society [Arshad et al., 2009]. In maize, a 3% green manure application produced the highest root and shoot biomass, surpassing the control and comparable to NPK fertilizer. However, insignificant effects were observed on mung bean growth and yield with NPK fertilizers and Parthenium green manure [Ahsan et al., 2020].

7.6 Synthesis of Nanoparticles: In the realm of traditional silver nanoparticle production, which often involves toxic chemicals posing risks to both individuals and the environment, a more efficient and environmentally friendly method known as green chemistry nanoparticle synthesis has emerged. Utilizing Parthenium hysterophorus leaf extract, silver nanoparticles (AgNPs) were successfully synthesized through this green chemistry approach [Sivakumar et al., 2021]. Another study explored the antibacterial and anticancer properties of silver nanoparticles produced from Parthenium hysterophorus leaf extract, indicating potential applications in the medical field [Mary et al., 2020]. Copper nanoparticles (CuNPs) produced using Parthenium hysterophorus leaf extract demonstrated notable inhibitory activity against various bacteria, showcasing an efficient and eco-friendly production process [Saha et al., 2013].

7.7 Bioethanol Production: Parthenium hysterophorus L., considered a problematic weed due to its high regenerative capacity and adaptability to various ecosystems, can be repurposed for bioethanol production. Research focused on biofuel technology has explored using ultrasound to ferment Parthenium hysterophorus biomass for bioethanol production [Nargotra et al., 2019]. Additional studies have investigated various methods, including ultrasound-assisted ionic liquid pretreatment and consolidated bioprocess fermentation, to efficiently convert Parthenium hysterophorus biomass into bioethanol [Tavva et al., 2016]. The potential of second-generation bioethanol synthesis using Parthenium biomass from non-agricultural sources has also been explored [Lata et al., 2007].

7.8 Heavy Metal and Dye Removal: Parthenium hysterophorus proves beneficial in addressing environmental concerns related to heavy metals and dyes in water bodies. Batch reactors utilizing Parthenium hysterophorus adsorbents effectively removed methylene blue from aqueous solutions. The weed demonstrated the capability to adsorb up to 90% of certain heavy metals and dyes [Bapat & Jaspal, 2016]. Studies have explored the use of Parthenium hysterophorus for bio-accumulation and removal of metals like Cd, Cr, Cu, Ni, and Pb from polluted soil, showcasing its potential for ecological remediation [Mary et al., 2021].

7.9 Medicinal Uses: Beyond its reputation as a troublesome weed, Parthenium hysterophorus has significant medicinal value. Traditionally, it has been utilized to treat various ailments such as skin irritation, rheumatic pain, diarrhea, urinary tract infections, dysentery, malaria, and neuralgia [Kumar et al., 2013]. Additionally, Parthenium hysterophorus extracts have demonstrated antioxidant properties and protection against membrane damage, making them a subject of interest in nanomedicine experiments [Kumar & Chashoo et al., 2013]. The phytochemicals in Parthenium hysterophorus leaf extracts have exhibited anti-cancer properties by destroying human cancer cells and displaying activities such as iron binding, hydroxyl radical scavenging, and lipo-protective effects [Siddiqui et al., 2018].

7.10 Mulching: Mulching, a practice that inhibits weed oxygen production through photosynthesis, offers a suffocating effect while providing additional benefits such as protection against the rainy season, improvement of soil quality, reduction of surface temperatures, conservation of moisture, and soil fertilization. The allelopathic actions of Parthenium hysterophorus herbage in mulching have been identified as advantageous for boosting soybean production under subhumid agroclimatic conditions while simultaneously minimizing weed infestations.

8. People Awareness on Parthenium: Efficient management of Parthenium at the national level necessitates widespread public engagement and knowledge. It is recommended that each participating unit organizes events such as Parthenium Awareness Day, Week, Fortnight, or Month. Awareness initiatives should encompass diverse activities, including live demonstrations, uprooting events involving people, students, and employees, picture exhibitions, film screenings, marches, among others. Constant media involvement is essential to continually raise awareness about the challenges posed by Parthenium [Singh et al., 2023]. Comparable to the impact of ragweeds in the US and chrysanthemums in Europe causing dermatitis, Parthenium poses health risks. Despite its pervasive presence, there is a general lack of public awareness regarding its harmful consequences. A cross-sectional study focusing on rural awareness of P. hysterophorus revealed this knowledge gap [Dheer et al., 2021]. Furthermore, ICAR institutes across India conducted a "Parthenium Awareness Week" from August 16th to August 22nd in 2021, 2022, and 2023, aiming to educate farmers about the negative consequences and control measures associated with Parthenium [Singh et al., 2023].

Conclusion: This review emphasizes that Parthenium hysterophorus exhibits allelopathic traits, causing harm to both animals and plants. Its rapid propagation, especially in arid regions and fertile land, distinguishes it from other weed species. Given the current population growth rate in India, there is a critical need to judiciously assess land usage for agriculture and forestry. To ensure progress, it is imperative to leverage all available resources that nature offers. Comprehensive understanding of the benefits and drawbacks associated with Parthenium is crucial for effective weed control. Access to accurate information empowers us to utilize various strategies, as discussed earlier. While the focus is on Parthenium, the principles outlined here can be applied to address challenges posed by other weed varieties.

References

1. Adkins, S. and Shabbir, A. Biology, Ecology and Management of the Invasive Parthenium Weed (Partheniumhysterophorus L.). Pest Management Science. 2014; 70, 1023-1029.
2. Ahsan A, Farooq MA, Ahsan Bajwa A, Parveen A. Green Synthesis of Silver Nanoparticles Using PartheniumHysterophorus: Optimization, Characterization and In Vitro Therapeutic Evaluation. Molecules. 2020; 22;25(15): 3324. doi: 10.3390/molecules25153324.
3. Ailey LH. Manual of cultivated plants, Macmillan, NewYork.1960
4. Ambasta SK, Kumari S. A scientific approach of conversion of eco-hazardous Parthenium weed into eco-friendly by compost making. Intl. J. Geo. Earth Environ. Sci. 2013; 3(1): 90-94.
5. Ambasta SK, Kumari S. A scientific approach of conversion of eco-hazardous *Parthenium* weed into eco-friendly by compost making. International Journal of Geology, Earth & Environmental Sciences. 2013: 3(1) 90–94
6. Ameta SK, Ameta R, Dave D, Ameta SC. An approach for bringing nutrients back into soil by composting weed Parthenium. 2016; 5(3): 052 - 058,
7. Aneja KR. Biotechnology: an alternative novel strategy in agriculture to control weeds resistant to conventional herbicides. Antimicrobial Resistance from Emerging Threats to Reality. 2009: 160–173.
8. Anjum T, Bajwa R, Javaid A. Biological Control of Parthenium I: Effect of Imperatacylindrica on distribution, germination and seedling growth of Partheniumhysterophorus L. Int. J. Agric. Biol. 2005; 7 (3): 448–450
9. Anonymous. White Top (Partheniumhysterophorus Caribbean Invasive Alien Species Network. 2010
10. Ashebir B, Sharma JJ, Lisanwork N. Allelopathic Effects of aqueous extracts and plant residues of *Partheniumhysterophorus* L. on kabuli chickpea and sesame. ETH J. Weed Mgt. 2012; 5: 13–26.
11. Awasthi A. Bio- accumulation of Cd, Cr, Cu, Ni and Pb in a wild grass, Partheniumhysterophorus L. Asteraceae, growing naturally on barren land and evaluation of phyto-extraction potential of the plant for studied metals. Asian Journal of Research in Chemistry 2023; 16(4):277-4. Doi: 10.52711/0974-4150.2023.00046
12. Ayana E, Ensermu K, Teshome S. Impact of Partheniumhysterophorus L. (Asteraceae) on soil chemical properties and its distribution in a reserve area: A case study in Awash National Park (ANP), Ethiopia. Journal of Soil Science and Environmental Management. 2015; 6(5): 116-124.
13. Bala SK, Bhattacharya P, Mukerjee KS, Sukul NC. Nematicidal properties of the plants Xanthium strumarium and Partheniumhysterophorus. Environ. Ecol. 1986; 4: 139-141.
14. Bapat S, Jaspal D. *Partheniumhysterophorus: Novel adsorbent for the removal of heavy metals and dyes*. Global Journal of Environmental Science and Management; Global Journal of Environmental Science and Management. 2016; , 2(2): 135-144 Doi: 10.7508/gjesm.2016.02.004
15. Batish DR, Singh HP, Pandher JK, Arora V, Kohli RK. Phytotoxic effect of Parthenium residues on the selected soil properties and growth of chickpea and radish. Weed Biology and Management 2002; 2(2): 73–78. Doi: 10.1046/j.1445-6664.2002.00050.x.
16. Bhateria R, Renu, Snehlata. Partheniumhysterophorus L.: Harmful and Beneficial Aspects - A Review. Nature Environment and Pollution Technology 2015; 14(3): 463-474
17. Bhateria R, Snehlata R. Partheniumhysterophorus L.: Harmful and beneficial aspects a review. Nat Environ PollutTechnol 2015; 14: 463-74.
18. Chamle DR, Raut SD, Jadhav B. Efficacy of Parthenium for Maize Production Journal of Developments in Sustainable Agriculture 2012; 7: 122-128.
19. Chitale RD, Mali BS. Potential use of Parthenium (Partheniumhysterophorus L.) as compost Eco. Env. & Cons. 2020; 26(1): 83-85

ISSN PRINT 2319 1775 Online 2320 7876

Research Paper **© 2012 IJFANS. All Rights Reserved**, UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

20. Dheer V, Kumar S, Singh J. Integrated Management of Partheniumhysterophorus L. Vigyan Varta 2023; 4(10): 162-165.
21. Dhileepan K, McFadyen R. Partheniumhysterophorus L. -Parthenium. CSIRO. 2012; 448-462
22. Dhileepan K. Effectiveness of introduced biocontrol insects on the weed *Partheniumhysterophorus* (Asteraceae) in Australia. *Bulletin of Entomological Research.* 2001; 91(3): 167–176.
23. Dhiman. Effects and Management of *Parthenium hysterophorus*: A Weed of Global Significance. *Int. Sch. Res. Not.* 2014; 368647.
24. Dolai AK, Bhowmick MK, Ghosh P, Ghosh RK. Utilization of congress grass (Partheniumhysterophorus L.) for soil fertility enhancement and improved productivity of potential crop sequences in West Bengal, Journal of Pharmacognosy and Phytochemistry 2019; 8(2): 2241-2245
25. Dukpa R, Tiwari A, Kapoor D. Biological management of allelopathic plant *Parthenium* sp. Open Agric. 2020; 5: 252–261.
26. El-Sayed W. Review biological control of weeds with pathogens: Current status and future trends. Journal of Plant Disease Protection. 2005;112(3): 209-221.
27. Etana A, Kelbessa E, Soromessa T. Impact of Partheniumhysterophorus L. (Asteraceae) on soil chemical properties and its distribution in a reserve area: A case study in Awash National Park (ANP). J. Soil Sci. EnvironmnetalManag. 2015; 6: 116–124. Doi:10.5897/JSSEM12.015.
28. Fisheries AA. Parthenium. Business Queensland. 2023.
29. Gajendran G, Gopalan M. Notes on the antifeedant activity of Partheniumhysterophorus L. on Spodopteralitura. Ind. J. Agric. Sci. 1982; 52: 203-205.
30. Girish S, Harshini M, Ravi L. A review on Parthenium sp. Asian Journal of Pharmaceutics. 2020; 14 (2): 156-162
31. Gitanjali G, Kumaresan A, Dharmaraj M, Karuppayee T. Utilization of parthenium plant leachate for biogas production. Asian Journal of Microbiology, Biotechnology and Environmental Sciences. 2009; 11(1) 113–115.
32. Gnanavel I. Partheniumhysterophorus L.: A Major Threat to Natural and Agro Eco-Systems in India. Science International. 2013; 1: 124-131.
33. Gul F, Khan IU, Rutherford S, Dai Z, Li G, Du D. Plant growth promoting rhizobacteria and biochar production from Partheniumhysterophorus enhance seed germination and productivity in barley under drought stress. Frontiers in Plant Science. 2023. Doi: 10.3389/fpls.2023.1175097
34. Gunaseelan VN. Parthenium as an additive with cattle manure in biogas production. Biol. Wastes. 1987; 21: 195-202.
35. Hailu G, Chimdessa M. Anaerobic Digestion of Parthenium Weed with Goat Manure to Generate Biogas Energy. International Journal of Energy and Power Engineering. 2020; 9(3): 35-40. Doi: 10.11648/j.ijepe.20200903.12
36. Hussain N, Abbasi SA, Abbasi SA. Vermicomposting transforms allelopathic parthenium into a benign organic fertilizer. Journal of Environmental Management; Elsevier BV 2016. Doi: 10.1016/j.jenvman.2016.05.013
37. Inderjit and S.O. Duke. Ecophysiological aspects of allelopathy. Planta. 2003; 217: 529-539.
38. Isman MB. Plant essential oils for pest and disease management. Crop Protection. 2000; 19: 603-608
39. Javaid A, Adrees H. Parthenium management by cultural filtrates of phytopathogenic fungi. Natural Product Research. 2009; 23(16); 1541–1551. Doi: 10.1080/14786410902726167
40. Javaid A, Anjum T, Bajwa R. Biological Control of Parthenium II: Allelopathic effect of Desmostachyabipinnata on distribution and early seedling growth of Partheniumhysterophorus L. Int. J. Biol. Biotech. 2005; 2(2): 459-463.

ISSN PRINT 2319 1775 Online 2320 7876

UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

41. Javaid A, Anjum T. Control of Partheniumhysterophorus L. by aqueous extracts of allelopathic grasses. Pak. J. Bot. 2006; 38: 139-145.
42. Javaid A, Anjum T. Partheniumhysterophorus L. — a noxious alien weed. Pakistan Journal of Weed
43. Jayanth KP, Ganga-Visalakshy PN. Succession of vegetation after suppression of Parthenium weed by Zygogrammabicolorata in Bangalore, India. Biological Agriculture and Horticulture. 1996; 12: 303-309.
44. Joshi S. Interference effect of Cassia uniflora Mill. on Partheniumhysterophorus L. Plant Soil. 1991; 132: 213-218
45. Kanagwa W, Kilewa R, Treydte AC. Effectiveness of *Zygogrammabicolorata* as a biocontrol agent against *Partheniumhysterophorus* in Arusha, Tanzania, Biocontrol Science and Technology. 2020; 30(8): 806-817. Doi: 10.1080/09583157.2020.1768219
46. Kanchan S, Chandra J. Pollen allelopathy- A new phenomenon. New Phytol. 1980; 84: 739–746.
47. Kaur A, Kohli RK. Biology and Management of Problematic Crop Weed Species. Science Direct. 2021
48. Kaur M, Aggarwal NK, Kumar V, Dhiman R. Effects and Management of Partheniumhysterophorus: A Weed of Global Significance. Int Sch Res Notices. 2014; 368647. doi: 10.1155/2014/368647.
49. Kaur M, Aggarwal NK, Kumar V, Dhiman R. Effects and Management of Partheniumhysterophorus: A Weed of Global Significance. Int Sch Res Notices. 2014; 1-12.
50. Kaur M, Aggarwal NK, Kumar V, Dhiman R. Effects and Management of *Partheniumhysterophorus*: A Weed of Global Significance. International Scholarly Research Notices. 2014; 368647: 1-12 Doi: 10.1155/2014/368647
51. Khaket TP, Aggarwal H, Jodha D, Dhanda S, Singh J. Partheniumhysterophorus in current scenario: A toxic weed with industrial, agricultural and medicinal applications. J. Plant Sci. 2015; 10: 42
52. Kishor P, Ghosh AK, Singh S, Maurya BR. Potential use of parthenium (*Partheniumhysterophorus* L.) in agriculture. Asian Journal of Agricultural Research. 2010; 4(4) 220–225.
53. Kumar D, Ahmed J, Singh S. Distribution and effect of PartheniumHysterophorus L. In Mehari sub-watershed of Rajouri Forest Range, J&K. International Journal of Scientific Research. 2013; 2(6): 304-306.
54. Kumar S, Chashoo G, Saxena AJ, Pandey AK. Partheniumhysterophorus: A Probable Source of Anticancer, Antioxidant and Anti-HIV Agents", BioMed Research International. 2013; 810734, Doi: 10.1155/2013/810734
55. Kumar S, Masto RE, Ram LC, Sarkar P, George J, Selvi VA. Biochar preparation from *Partheniumhysterophorus* and its potential use in soil application. *Ecological Engineering*. 2013; 55: 67–72
56. Kumar, S., Mishra, A. & Pandey, A.K. Antioxidant mediated protective effect of *Partheniumhysterophorus* against oxidative damage using *in vitro* models. *BMC Complement Altern Med* 2013;13: 120 Doi: 10.1186/1472-6882-13-120
57. Kumari P, Sahu PK, Soni MY, Awasthi P. Impact of Partheniumhysterophorus L. Invasion on Species Diversity of Cultivated Fields of Bilaspur (C.G.) India. Agricultural Sciences. 2014 (5): 754-764.
58. Lata H, Garg VK, Gupta RK, Removal of a basic dye from aqueous solution by adsorption using Partheniumhysterophorus: An agricultural waste, Dyes and Pigments, 2007; 74(3) 653-658.
59. Mary FJ, Kumar MS, Vignesh K, Vijaykumar E, Yadeshwaran G, Yamuna V, Yuvalakshmi E. Partheniumhysterophorus: Weed of Pharmacological Importance Journal of University of Shanghai for Science and Technology. 2021; 23(10)

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

60. Mary RS, Mahesh MK, & Pruthvi ML. Biosynthesis of Copper Nanoparticles Using PartheniumHysterophorus Leaf Extract and Screening Its Antimicrobial Activity. Asian Journal of Pharmaceutical and Clinical Research, 2020; 13(1): 93–99. Doi: 10.22159/ajpcr. 2020.v13i1.36076
61. Mayo ZA, Abbas S. Impact of parthenium weed on the yield of wheat crop in Sheikhupura and Rawalpindi districts of the Punjab, Pakistan. Pakistan Geographical Review. 2020; 75(2): 301-314
62. McConnachie AJ, Strathie LW, Mersie W, Gebrehiwot L, Zewdie K, Abdurehim A, Abrha B, Araya T, Asaregew F, Assefa F. Current and potential geographical distribution of the invasive plant *Partheniumhysterophorus* (Asteraceae) in eastern and southern Africa. Weed Res. 2011; *51*, 71–84.
63. Murthy RK, Raveendra HR, Manjunatha RTB. Effect of Chromolaena and Parthenium as green manure and their compost on yield, uptake and nutrient use efficiency on TypicPaleustalf. European Biological Sciences. 2010; 4(1) 41–45.
64. Nargotra P, Sharma V, Bajaj BK. Consolidated bioprocessing of surfactant-assisted ionic liquid-pretreatedPartheniumhysterophorus L. biomass for bioethanol production. Bioresour Technol. 2019; 289: 121611. Doi: 10.1016/j.biortech.2019.121611.
65. Navie SC, McFadyen RE, Panetta F.D, Adkins SW, The biology of Australian weeds in Partheniumhysterophorus L. Plant Prot. Q. 1996; (11): 76–88.
66. Nigatu L, Hassen A, Sharma J, Adkins SW. Impact of Partheniumhysterophorus on grazing land communities in North-Eastern Ethiopia. Weed BiolManag 2010; 10: 143-52.
67. O, Donnell, C. and S.W. Adkins. 2005. Management of Parthenium weed through competitive displacement with beneficial plants. Weed Biol. Manag., 5:77-79
68. Pal, R. K., Maurya, D. K., Kumar, S., & Singh, R. (2023). Assessing the Influence of Nano Urea on the Growth and Yield of Irrigated Wheat (Triticum aestivum L.) Crop. *International Journal of Environment and Climate Change*, *13*(12), 843-851.
69. Pandey DK, Kauraw LP, Bhan VM. Inhibitory effect of Partheniumhysterophorus residue on growth of water hyacinth (Eichhornia crassipes). J. Chem. Ecol. 1993;19: 2651-2662.
70. Patel S. Harmful and beneficial aspects of Partheniumhysterophorus: an update. 3 Biotech. 2011; 1(1): 1-9. doi: 10.1007/s13205-011-0007-7.
71. Patel S. Harmful and beneficial aspects of Partheniumhysterophorus: an update. *3 Biotech*, 2011; 1(1): 1–9.
72. Prahalad Singh, Ravikesh Kumar Pal, Naveen Kumar Maurya, Vineet Dheer, Mahendra Yadav, Rajat Yadav, Divyansh Mishra, Ankit Kumar. Effect of different herbicidal weed management practices in wheat (Triticumaestivum L.). Pharma Innovation 2023;12(7):2872-2878.
73. Ray P, Gour HN. Integrated management of Partheniumhysterophorus L. (Asteraceae): A weed of worldwide significance. Indian Society of Mycology and Plant Pathology. 2012; 5: 605-632.
74. Sankaran KV. Partheniumhysterophorus. Newsletter of the Asia-Pacific Forest Invasive Species Network. 2007; 9;1-6
75. Sankaran KV. Partheniumhysterophorus. Newsletter of the Asia-Pacific Forest Invasive Species Network. 2007; 9;1-6
76. Sankaran KV. Partheniumhysterophorus. Newsletter of the Asia-Pacific Forest Invasive Species Network. 2007; 9;1-6
77. Sankaran KV. Partheniumhysterophorus. Newsletter of the Asia-Pacific Forest Invasive Species Network. 2007; 9;1-6
78. Shabbir A, Sadia S, Mujahid I. Biocontrol efficiency of Zygogrammabicolorata at different growth stages of Partheniumhysterophorus. Indian Journal of Weed Science; Indian Society of Weed science. 2016; 48(4): 460-463 Doi: 10.5958/0974-8164.2016.00120.9

79. Sharma R, Dwivedi HS, Dwivedi P. Utilization of three obnoxious weeds (Partheniumhysterophorus, Lantana camara and Eichhornia crassipes) through vermicomposting and their response on vegetative growth of Soybean crop. Int. J. Adv. Res. Biol. Sci. 2016; 3(9): 13-20
80. Sharma S K, Dash S, Shukla P. A Survey-Based Assessment of Awareness Regarding Partheniumhysterophorus in a Rural Population of North India. Cureus. 2023; 15(7): e41453. Doi:10.7759/cureus.4145
81. Sharma VK, Verma P, Maharaja K. Partheniumhysterophorus dermatitis. PhotochemPhotobiol Sci. 2013; (12): 85-94
82. Shi B, Dhileepan K, Adkins S. The Impact of Parthenium Weed-Amended Substrates on the Germination and Early Growth of a Range of Pasture and Crop Species. Agronomy. 2021; 11(9): 1708. Doi: 10.3390/agronomy11091708
83. Shi B, Dhileepan K, Adkins S. The Impact of Parthenium Weed-Amended Substrates on the Germination and Early Growth of a Range of Pasture and Crop Species. Agronomy. 2021; 11(9): 1708. Doi: 10.3390/agronomy11091708
84. Singh CK, Kumar A. Vermicomposting of terrestrial weeds Lantana camara L. and Partheniumhysterophorus L.:agriculture solid waste. Ecological Questions 2018. Doi: 10.12775/eq.2017.040
85. Singh HP, Batish DR, Setia N, Kohli RK. Herbicidal activity of volatile oils from Eucalyptus citriodora against Partheniumhysterophorus. Ann ApplBiol 2005; 146: 89-94.
86. Singh HP, Batish DR, Setia N, Kohli RK. Herbicidal activity of volatile oils from Eucalyptus citriodora against Partheniumhysterophorus. Annals of Applied Biology. 2005; 146(1): 89–94. Doi: 10.1111/j.1744-7348.2005.04018.x
87. Singh PK, Pawar D, Gharde Y, Kumar S, Dhagat S. Integrated Management of Parthenium. ICAR-DWR. 2023; 68: 1-6
88. Singh PK, Pawar D, Gharde Y, Kumar S. Advisory Note on Parthenium Management. ICAR_DWR. 2023
89. Singh PK, Pawar D, Gharde Y, Kumar S. Join hands to eliminate Parthenium to save health, environment and biodiversity. ICAR_DWR. 2023
90. Singh S, Sarma S, Agarwal M, Goyal A, Moholkar VS. Ultrasound enhanced ethanol production from Partheniumhysterophorus: A mechanistic investigation. Bioresour Technol. 2015; 188: 287-94. Doi: 10.1016/j.biortech.2014.12.038.
91. Sivakumar M, Surendar S, Jayakumar M. *Partheniumhysterophorus* Mediated Synthesis of Silver Nanoparticles and its Evaluation of Antibacterial and Antineoplastic Activity to Combat Liver Cancer Cells. J Clust Sci. 2021; 32: 167–177. Doi: 10.1007/s10876-020-01775-x
92. Tamado T, Ohlander L, Milberg P. Interference by the weed Partheniumhysterophorus L. with grain sorghum: influence of weed density and duration of competition. Int. J. Pest Manage. 2002; (48): 183-188.
93. Tavva SSMD, Deshpande A, Durbha SR, Palakollu VAR, Goparaju AU, Yechuri VR, Bandaru V, Muktinutalapati VSR. Bioethanol production through separate hydrolysis and fermentation of Partheniumhysterophorus biomass. Renewable Energy; Elsevier BV. 2016. Doi: 10.1016/j.renene.2015.09.074
94. Timsina B, Shrestha BB, Rokaya MB, Münzbergová Z. Impact of *Partheniumhysterophorus* L. invasion on plant species composition and soil properties of grassland communities in Nepal. Flora Morphol. Distrib. Funct. Ecol. Plants 2011; 206: 233–240
95. TolikaSwu, Christy BK Sangma, LK Baishya. Vishishta Composting: Short duration, Eco-friendly recipe for Detoxification of Partheniumhysterophorus L. MorungExpress. 2022
96. USDA. Partheniumhysterophorus". Germplasm Resources Information Network. Agricultural Research Service, United States Department of Agriculture. 2010.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

97. Vélez-Gavilán, J, Shabbir A; Parker C. *Partheniumhysterophorus* (parthenium weed). *Invasive Species Compend.* 2019; 45573.
98. Vineet Dheer, Mohit Yadav, Rohit Yadav. Effect of post emergence herbicides on weed density in wheat (Triticumaestivum L.). Pharma Innovation2021;10(10):440-443.
99. Vyankatrao NP. Conversion of Partheniumhysterophorus L. Weed to compost and vermicompost Bioscience Discovery. 2017; 8(3): 619-627.
100. Wahab S. Management of *Parthenium* through an integrated approach initiatives, achievements and research opportunities in India. Proceedings of the 2nd International Conference on Parthenium Management, 2005; 36–43.
101. Weyl P. Partheniumhysterophorus (parthenium weed). *CABI Compendium*. 2022
102. Yadav N, Saha P, Jabeen S. Effect of methanolic extract of Partheniumhysterophorus on haematological parameters in wistar albino rat. The Bioscan—International Journal of Life Sciences. 2010 (2): 357–363