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Parthenium Weed: A Major Threat to Biodiversity in India

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ABSTRACT

Parthenium hysterophorus is commonly known as congress grass or carrot weed. It is also called as white cap or top, gajari, gajar ghans, chatak chandani, nakshtra gida, safed topi etc. It is most commonly called as 'Gajar Ghans' as it appears like carrot plant. It is herbaceous, an annual plant belonging to subfamily Heliantheae and family Asteraceae (Compositae). It is a deadly weed infesting cropped and non-cropped areas. This weed rapidly covers the new surroundings and poses a serious threat to our environment. This weed has been rapidly spreading from the last two decades. *Parthenium hysterophorus* is a noxious weed in America, Asia, Africa and Australia. This weed is considered to be a cause of allergic respiratory problems, contact dermatitis, mutagenicity in human and livestock. Crop production is drastically reduced owing to its allelopathy. Also, aggressive dominance of this weed threatens biodiversity. It can be seen on roadside, railway tracts, vacant lands, wastelands, agricultural, horticultural and plantation crops, industrial areas, irrigation canals etc. Presently it is considered as one of the most problematic weeds. Its invasion in India has been estimated to be about 35 million hectares. It has wide adaptability to climate and soil conditions. It grows luxuriantly and does not allow any other vegetation nearby or underneath. It has been observed that this weed has reduced crop yields and has also affected biodiversity in the state. The weed is very common along with the road sides, around the agricultural fields and on waste lands. *P. hysterophorus* is considered as a noxious weed because of its prolific seed production and fast spreading ability, allelopathic effect on other plants, strong competitiveness with crops and health hazard to human as well as animals. The infestation of the weed causes yield losses up to 40% in several crops and reduces forage production by up to 90%. The rapid spread of parthenium in India would be a bigger risk to the expansion and sustainable production of many crops.

Keywords: Parthenium, biodiversity, allelopathic, weed,

INTRODUCTION

Parthenium hysterophorus is a flowering plant of the family Asteraceae and native to the American tropics (USDA, 2009). Common names include

Santa-Maria (BSBI_List, 2007 Santa Maria feverfew, (USDA, NRCS, 2016) white top weed and famine weed (McConnachie *et al.* 2011). In India, it is locally known as carrot grass, congress grass or *Gajar Ghas* (Oudhia *et al.* 2000). It is a common invasive species in India (Oudhia, 2000), Australia, and parts of Africa (McConnachie *et al.* 2005). This plant causes contact dermatitis and respiratory malfunction in humans, and dermatitis in cattle and domestic animals. The main substance responsible is parthenin, which is dangerously toxic (The Hindu. Chennai, 2003). It also is responsible for bitter milk disease in livestock if their fodder contains *Parthenium* leaves. (The Hindu, 2003) Among other allelopathic effects of the species, the presence of *Parthenium* pollen grains inhibits fruit set in many vegetables and a number of other crop plants.

In India, it was first recorded in 1810 in Arunachal Pradesh and Nagaland and in Pune in 1955. By 1972, it had spread into the majority of the western states from Kashmir in the north to Kerala in the south. Continuing to spread it was found in Assam in 1979 and is now present almost throughout the subcontinent and is probably the dominant weed in Karnataka State. Parthenium weed has been reported from all states of India. In general, the overall spread in terms of density and infestation level is that it is highest in Andhra Pradesh, Bihar, Chhatisgarh, Delhi, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Punjab, Tamil Nadu and Uttar Pradesh. The spread and infestation level is medium in Assam, Gujarat, Himachal Pradesh, Jharkhand, Jammu and Kashmir, Uttarkhand, Orissa, West, Bangal and Rajasthan states while spread is low in Andaman and Nicobar, Arunachal Pradesh, Daman and Diu, Goa, Kerela, Manipur, Mizoram, Mehgalaya, Nagaland, Pondicherry and Sikkim (Gnanavel, 2013; Lalita and Kumar, 2018)

At present, parthenium weed has become widely distributed throughout India. Now it has achieved the status of the countries “Worst Weed” due to its allelopathic effects on crop production and harmful effects on people and animals. During the 1980s, parthenium weed used to be considered a weed of rainfed fallow and wasteland but now it has become a weed of every crop and also into the forested land. The severity of the parthenium weed problem has compelled researchers and people from various action groups and societies to provide a forum for those in need and affected by parthenium weed.

Morphology and Biology

Parthenium hysterophorus is a much-branched, annual, erect herbaceous plant that forms a basal rosette of leaves during the early stage of growth. It usually grows 0.5-1.5 m tall, but sometimes it reach up to 2 m or more in height. Mature stems are greenish and grooved, covered in small stiff hairs, and become much branched at maturity. The alternately arranged leaves are simple with petioles up to 2 cm long and form a basal rosette during the early stages of growth. The lower leaves are relatively large (3-30 cm long and 2-12 cm wide) and are deeply divided. Leaves on the upper branches decrease in size and are also less divided than the lower leaves. The undersides of the leaves, and upper surfaces to some extent, are covered with short, stiff hairs that lie close to the surface. Numerous small flower-heads (capitula) are arranged in clusters at the tips of the branches (in terminal panicles). Each capitulum is borne on a 1-8 mm long pedicel. These flower-heads are white or cream in colour and have five tiny 'petals' (ray florets) 0.3-1 mm long. They also have numerous (12-60) tiny white flowers (tubular florets) in the centre and are surrounded by two rows of small green bracts called involucre. Colour changes to light brown when seeds are mature and about to shed. Flowering can occur at any time of the year, but is most common during the rainy seasons. Five small 'seeds' (achenes) are usually produced in each capitulum. These achenes (1.5-2.5 mm long) consist of a black seed topped with two or three small scales (a pappus) about 0.5-1 mm long, two straw-coloured papery structures (actually dead tubular florets), and a flat bract.

Habitat

P. hysterophorus is a pioneer species which can invade in almost all places. According to the Corine Land Cover nomenclature, the following habitats are invaded; arable land, permanent crops, pastures, banks of continental water, riverbanks or canal sides, road and rail networks and associated land, other artificial surfaces (wastelands). Parthenium is a drought-tolerant plant and can grow in almost all soil types (Mahadevappa, 1997). This weed can grow over a wide range of moisture and temperature conditions but requires high soil moisture for seed germination (Singh *et al.* 2004). It is photoperiod and thermoperiod insensitive and can flower year-round (Mahadevappa, 1997). Seed germination can take place over a wide range of temperatures (Tamado *et al.* 2002) and soil pH (Ahlawat *et al.* 1979). Parthenium is very

competitive and has been reported to gain an advantage over a C_4 pasture grass (*Cenchrus ciliaris*) as atmospheric CO_2 concentrations increase, despite being a C_3 plant. This is fairly typical of the response of C_3 and C_4 plants when grown in enriched CO_2 atmospheres.

Allelopathic potential

This weed suppresses the development of nearby plants by allelopathy. Leachate and extract of leaves and inflorescence inhibits the germination and growth of some important crops. Kumari *et al.* (2014) observed that physiological and biochemical parameters remarkably reduced when aqueous extract of *Parthenium* were directly sprayed on the crop plants. *Parthenium* has strong allelopathic effects on other plants even it can cause 40-80% yield loss in agricultural crops.

a. Impact on Biodiversity

This weed has the potential to disturb the natural ecosystem, as it can grow throughout the year in almost all drastic conditions suppressing native vegetation. Owing the absence of effective natural enemies, its allelopathic effect as well as photo insensitivity and thermo insensitivity, it is a threat for natural diversity. Species richness, evenness and local biodiversity gradually decrease where this plant is present, this situation clearly indicates the native biodiversity loss of weeds and other crop plants due to *Parthenium* infestation. Its infestation is coupled with its allelopathic potential and the absence of its natural inhibitors such as pathogen, insects and their larvae. These are some important factors which are the reason of its luxurious growth and spread (Oudhia, 2001). The concentrations of allelochemicals like Coronopilin, caffeic acid, parthenin, and p-coumaric acid which are present in *Parthenium* have serious allelopathic effects.

Infestation by parthenium degrades natural ecosystems. With the passage of time; parthenium invasion enriches the compositional diversity but may result in extinction of native species (Noss, 1990). It is known to exert significant impact on the natural communities causing their displacement and hence exert imbalance in the natural and agricultural ecosystem (Sakai *et al.* 2001). This imbalance causes the formation of large monoculture of invasive alien plants in the environment. Several studies revealed the adverse effects of parthenium weed on plant biodiversity (Cock, 2001; Kohli *et al.* 2004).

- It is an aggressive colonizer that gets established in natural and manmade ecosystems, grassland habitats, open woodlands, river banks, flood plains, wildlife parks, open fields of settlements areas, bare areas along roadsides, crop fields, gardens heavily stocked areas around yards and watering points etc (Singh *et al.* 2005)
- It produces large amounts of seeds and thus, it has the potential to become widespread
- The allelochemicals released directly from the weed or from seed leaching inhibit germination of other plants and the growth of pasture grasses, legumes, cereals, vegetables, other weeds and even trees (Singh *et al.* 2005)
- It induces changes in the physical and chemical properties of soil such as soil texture, soil pH, soil organic matter, soil nitrogen, soil potassium, soil phosphorus etc. Manual removal is difficult because it may cause dermatitis, hay fever, asthma, allergic and even death in humans (Bhowmik *et al.* 2007)
- It is noxious and unpalatable to herbivores.
- It replaces rangelands palatable grasses and adversely effecting animals health damaging milk and meat quality (Wegari, 2008).

b. Impact on agriculture

The *Parthenium hysterophorus* weed has infested in a large area of India. This plant contains parthenin, hysterin, hymenin, and ambrosin. Due to the presesnce of these allelochemicals this weed has strong allelopathic impacts on different crops and human being also **(**Joshi, 1991**).** This weed have adverse impacts on legumes by disturbing their symbiosis with Nitrogen fixing bacteria such as *Rhizobium*, *Azotobacter, Azospirillum* and Actinomycetes. It produces huge numbers of pollens (Approx. 700 million), which travels a long distance from source plant to other crop plants and inhibits the fruit setting in these crop plants such as tomato, brinjal, beans, and ceraels.

- *P. hysterophorus* aggressively colonises disturbed sites and causes major negative impacts on pastures and crops. It competes strongly with crops such as sunflower and, in infested sorghum; *P. hysterophorus* suppresses yield, as well as contaminating the grain samples.
- It affects nodulation in legumes due to inhibition of activity of nitrogen fixing and nitrifying bacteria

viz., *Rhizobium*, *Actynomycetes*, *Azotobactor* and *Azospirillum.*

- It was reported to cause yield losses of up to 40% in several crops (Khosla and Sobti, 1979) and is reported to reduce forage production by up to 90% (Nath, 1981). *Parthenium* produces enormous quantity of pollen (on an average 624 million/plant), which is carried away at least to short distance in clusters of 600-800 grains and settles on the vegetative and floral parts, including stigmatic surface inhibiting fruit setting in crops like tomato, brinjal, beans, capsicum and maize when its pollen grains are deposited on the stigmatic surfaces (Singh *et al.* 2004).
- The weed acts as an alternate host for many diseases caused by viruses in crop plants.
- It also acts as an alternate host for the insect mealy bug.
- In Ethiopia, the yield in *Sorghum bicolor* grain was reduced from 40-97% when *P. hysterophorus* was left uncontrolled throughout the season.
- In Queensland (Australia), the species has invaded 170,000 km^2 of high quality grazing areas and losses to the cattle industry 8. Parthenium weed seed is also a contaminant of grain, pasture and forage seeds. Hence, it results in restricted sale and movement of these produces (Oudhia, 2001).

c Impact on Soil Micro flora

Parthenium showes inhibitory effect on growth and activity potential of different bacterial species related to Nitrogen assimilation such as Rhizobium and Azotobacter and nitrifying bacteria like Nitrosomonas. Aqueous extract of Parthenium has detrimental effects on the growth of Rhizobium, Nitrosomonas and Azotobacter. It reduced the Legheamoglobin content of root nodules by which Rhizobium legume symbiosis is affected. Leaf and root leachates and their chemical component inhibit nitrate production (Sukhada and Jaychandra 1981). Apart from this it can inhibit the growth of algae and mycorrhizae associated to crop plants because of its fungicidal property (Megharaj *et al.* 1987).

d. Impact on crops

P. hysterophorus is reported to exert negative allelopathic influence to its neighbouring plant species (Towers et.al. 1977). The chemical analysis has indicated that all the plants parts including trichomes and pollen contain toxin called parthenin of sesquiterpene lactones group. Other compounds include phenolics such as caffic acid, vanilic acid, ρ-cumaric acid, anisic acid, ρ-anisic acid, ferulic acid and chlorogenic acids. The leaves and inflorescence of *Parthenium* have higher level of allelochemicals than the stem and roots. These allelochemicals affect other plants either directly by leaching, root exudation and residue decay or indirectly, ultimately leading to loss of native flora (Wiesner *et al.* 2007). Parthenin, caffeic acid and ρ-coumaric acid are the primary inhibitors present in this plant; other chemicals are hysterin, hymenin and ambrosin (Singh and Kour, 1997). The sesquiterpene group includes parthenin, coronopilin, 2-β hydroxy coronopilin, tetraneurine A, hysterones A-D (Towers and SubbaRao, 1992). and seco-pseudoguinaloides found in the form of charminarone (Chippendale and Panetta, 1994.). The allelochemicals released from parthenium inhibit the growth of pasture grasses, legumes, cereals, vegetables, other weeds and even trees (Batish *et al.* 2005.). Several studies (Mersie and Singh, 1988) investigated the effect of parthenium allelochemicals on other plants. It was found that the plant residue of parthenium was toxic to aquatic flora and fauna (Kanchan and Jayachandra 1979). The allelochemicals released from parthenium affecting many plant species are sesquiterpene lactones and phenolics. Parthenin is the major sesquiterpene lactone whereas caffeic, vanillic, ferulic, chlorogenic and anisic acids are the major phenolics (Ramesh *et al.* 2003). These two synergistically acting groups of allelochemicals significantly decrease the seed germination and subsequent growth in many crops **(**Anonymous, 2000**).** This plant contains parthenin, hysterin, hymenin, and ambrosin. Due to the presesnce of these al-lelochemicals this weed has strong allelopathic impacts on different crops and human being also (Gunaseelan, 1987). This weed have adverse impacts on legumes by disturbing their symbiosis with Nitrogen fixing bacteria such as Rhizobium, Azoto-bacter, Azospirillum and Actinomycetes. It produces huge numbers of pollens (Approx. 700 million), which travels a long distance from source plant to other crop plants and inhibits the fruit setting in these crop plants such as tomato, brinjal, beans, and ceraels.

e. Impact on human health and animals

The major toxic component parthenin and other phenolic acids such as caffeic acid, vanillic acid, ansic acid, ρ-anisic acid, chlorogenic acid and parahydroxy benzoic acid are lethal to human beings and animals (Singh *et al.* 2002**.**):

- Because of sesquiterpene lactone compounds, parthenium induce severe dermatitis and allergic symptoms in human beings.
- Parthenium pollen causes nasobronchial allergy with 42.5% of a large population in Bangalore, India showing sensitivity to pollen
- It is also reported to cause itching, popular erythmatous eruptions, loss of hair, marked depigmentation of skin, development of oedema ulceration and lesions in the mouth and intestine (Pandey, 1997)
- Parthenium causes general illness, asthmatic problems, irritations of skin and pustules on hand balls, stretching and cracking of skin and stomach pains on human (Swaminathan, 1990)
- It is a major cause of Trinities and Sinusitis, affecting about ten percent of the people who live near it (Singh *et al.* 2004.)
- Due to its irritating odour, taste and presence of trichome hairs, parthenium weed is unpalatable, but cattle and sheep will eat it when feed is scarce. Consumption of large amount will cause clinical signs such as those of sanitation anorexia, pruritus and alopecia and gastro-intestinal irritation may result in diarrhea
- Being toxic to livestock, causing both acute and chronic toxicity, a noticeable reduction in milk yield, tainting of milk with parthenin, depigmentation of skin, tainting in mutton and bitter taste in milk have been reported (Batish *et al.* 2007.) Frequent contact with the plant stock or its pollen can produce serious allergic reactions such as dermatitis, hay fever and asthma in live especially horses.

Management of *Parthenium hysterophorus*

It is necessary to control the problematic weed *P. hysterophorus* in time before spreading, because of its negative impact on natural and agro ecosystems. There are several methods available for controlling the parthenium weed. The methods are; manual and mechanical control, chemical and biological control and managing the weed by proper utilization. Manual and mechanical methods is one of the most common methods for management among the rural population of India. Farmers manage parthenium weed within their crop field by uprooting or hoeing the plants out. Uprooting the weed manually when the soil is wet and slashing with sword, collecting and burning the weed before flowering are some of the effective means of control. However, they don't care to manage the parthenium weed along the adjoining road side, wasteland or fallow land which soon causes re-infestation of the weed into their fields. Uprooting the weed after seed setting will increase the area of infestation. The manual removal is usually neither very effective nor economical, because of the rapid re-growth requiring repeated removals for season-long control. Moreover, it is hard to get labour solely for parthenium weed uprooting as labours fear the ill effects caused by this plant. Pulling a plant in flower will aid in the dispersal of pollen grains, resulting in allergic reactions (Gnanavel, 2013)

Management of *Parthenium* strategy needs to be shifted towards non-chemical methods. Managing weeds using biological means is less expensive, permanent and pollution free. Biological control is the intentional manipulation of natural enemies by man for the purpose of controlling harmful weeds. Parthenium is mainly a weed of waste and fallow land; hence bio-control is the most economical and practical way to keep the weed under check. Biological control of parthenium is the most cost-effective, environmentally safe and ecologically viable method. Several insects and pathogens have been tried from time to time for controlling the weed. The leaf-feeding beetle Z*ygogramma bicolorata* and the stem-galling moth *Epiblema strenuana* are widely used in several countries to manage Parthenium. *Z. bicolorata* is now widely used in India to control Parthenium. The moth significantly reduces flower and seed production of the weed, especially at a young age. It has a relatively high reproduction in a short period of time. In 1983, a chrysomelid beetle *Z. bicolorata* was imported from Mexico for the management of parthenium. Host specificity tests were conducted with 40 plant species belonging to 25 families and the insect was declared to be safe to economic plants. Adults and larvae of *Z. bicolorata* feed on Parthenium leaves. The early stage larvae feed on the terminal and auxiliary buds and move on to the leaf blades as they grow. The full-grown larvae enter the soil and pupate. An insect density of one adult per plant caused skeletonization of leaves within 4-8 weeks provided this density is achieved early in the rainy season. In India, *Z. bicolorata* became abundant within three years after introduction, resulting in a significant reduction in parthenium density in local areas. Other major biocontrol agents used are *Listronotus setosipennis,* (stem-boring weevil), *Smicronyx lutulentus* (seed-feeding weevil), *Bucculatrix parthenica* (leaf-mining

moth), *Platphalonidia mystica* (stem-boring moth), *Conotrachelus albocinereus* (stem-galling weevil) and *Carmenta ithacae* (rootboring moth) (Gnanavel, 2013).

CONCLUSION

It can be concluded from the present review article that we cannot decline the allelopathic and negative impacts of *Parthenium hysterophorus* on crop plants and livestock. This weed spread more rapidly in compare to other weeds. It covers many areas of agriculture lands as well as bare lands. At the present time of population explosion in India, it is necessary to use lands properly for agriculture as well as forestry. It is necessary that we can use every resource of nature for the improvement. We can control this weed through its management and it would happen when we have the proper knowledge about the beneficial and harmful effect of Parthenium. When we have proper knowledge of we can use it in different prospective which we have discussed above. This is not about the Parthenium although it should be applied for other weeds also.

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