



Commercial way of utilization of parthenium hysterophorus for strategic weed management

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ABSTRACT

Parthenium (*Parthenium hysterophorus* L.) is an invasive herbaceous weed which belongs to the family Compositae. In India it is believed to have been introduced in the 1950s and currently covering almost all parts of the country causing up to yield reduction in crop fields. *Parthenium hysterophorus*, one of the world's most dangerous weeds, is responsible for huge losses to the biodiversity, agriculture, economy, and health of livestock and human beings. High competitive success rate and adaptability of the species enable it to dominate diverse types of habitats. Various weed control strategies are being used globally to reduce its population to manageable levels. But owing to many limitations associated with the conventional methods, management of Parthenium still remains a challenge. Ever increasing demand of food and simultaneously decreasing arable land have put a big question mark over the future food supply. Side by side, extensive use of synthetic fertilizers, pesticides, and herbicides in agroecosystems has challenged the agricultural sustainability, food quality, and environmental safety. In these circumstances, the world scientific community is looking for other sustainable, cheaper, and ecofriendly alternatives. The attention is usually focused on reducing overreliance on synthetic pesticides and herbicides to find better alternative strategies for pest and weed management. In this regard, allelopathy has great prospects for meeting some of these demands. The allelopathic potential can be used in several ways not only in agroecosystems, but also in natural degraded ecosystem managements. The proceeding discussions in this chapter will explore multifarious prospects of allelopathy in the service of humanity and nature. Recently large scale utilization has been taken up as a holistic approach for the control of weeds. *Parthenium hysterophorus* can be managed by exploiting this weed in diverse fields. In the present studies the allelopathic potential was studied in laboratory and in field conditions with the objectives to explore the potential of *P. hysterophorus* as bioherbicide in future. Laboratory based experiment showed that with the increasing concentration of *P. hysterophorus*, the germination percentage, seedling length and seedling weight of all the three species tested was significantly decreased.

Keywords: *P. hysterophorus*, Allelopathic potential, Bioherbicide.

INTRODUCTION

Parthenium hysterophorus, members of the Asteraceae family is a noxious weed in America, Asia, Africa and Australia. This weed is considered to be a cause of a spectrum of clinical patterns: allergic respiratory problems, contact dermatitis, mutagenicity in human and livestock. Its allelopathic nature can drastically reduced the crop production and aggressive dominance of this weed threatens biodiversity. Attempts to control spread of the plant have so far not been successful. On the other hand, *P. hysterophorus* confers many health benefits, like remedy for skin inflammation, rheumatic pain, diarrhoea, urinary tract infections, dysentery, malaria, psoriasis, allergies, asthma, tinnitus, dizziness, nausea, vomiting, neuralgia. This plant traditionally used for the treatment of fevers, migraine headaches, rheumatoid arthritis, stomachaches, toothaches, insect bites, infertility, and problems with menstruation and labor during childbirth. The plant contains a large number of important bioactive compounds, mainly sesquiterpene lactones, flavonoid glycosides and pinenes. It has multiple pharmacologic properties, such as anticancer, anti-inflammatory, cardiogenic, antispasmodic, an emmenagogue, and as an enema for worms. The aim of this review article is to explore the toxicological reports of *P. hysterophorus*, summarized the active compounds responsible for different pharmacological properties, (Maharjan *et al.*, 2007). Many new methods are also being developed to manage *P. hysterophorus*. However, no single method is promising enough to eradicate it effectively. In the past few years, research in different parts of the world has been dedicated. Exploiting this allelopathic nature, *P. hysterophorus* can be a potential source of bio herbicide in future.

Economic Importance

Though *P. hysterophorus* is an obnoxious herb, when exploited by proper means and technology, it can prove to be a valuable asset. In West Indies this weed is used as a remedy against ulcerated sores, certain skin disease, facial neuralgia, fever and anaemia (Bhatt *et al.*, 2012) Chemical constituents are useful as insecticide and for curing psoriasis (Kohli and Rani, 1994). A preparation with and ginger is effective for treating migraines during the early pain phase (Kuhn and Winston, 2007).

Its broad-spectrum ovicidal, antimicrobial, lervicidal, nematocidal, herbicidal activities designate the improvement of public health and crop production (Bhatt *et al.*, 2012). Greenish yellow dye mordant with chrome produced from stems and leaves is used in wool processing (Kowalchik *et al.*, 1998). It is useable as an additive with cattle manure in biogas production (Patel, 2011).

Pesticidal Activity: the most effective as an insecticide against the adults of store grain pest *Callosobruchus maculatus* (Datta and Saxena, 2001). Petroleum ether extracts of leaves, stem and inflorescence of *P. hysterophorus* at 500, 1000, 2000 and 5000 ppm concentrations significantly decreased the life span and progeny production of mustard aphid, *Lipaphis erysimi* (Sohal *et al.*, 2002).

Against Mosquitos: *P. hysterophorus* feeding reduced the survival time and fecundity of *Anopheles gambiae*, (Manda *et al.*, 2007). 1,000 ppm diethyl ether extract from the leaves of *P. hysterophorus* was found to be the most effective in *Aedes aegypti* mosquitos in maximum effective repellency (99.7%) leading to the highest levels of reduced fecundity and 100% egg mortality followed by 1,000 ppm benzene extracts causing 93.8% reduced oviposition and 100% ovicidal effect (Kumar *et al.*, 2011). The ethanolic extract of leaves showed 83- 90% larvaecidal activity against *Anopheles stephensi* larvae (Ahmad *et al.*, 2011).

To find economic importance of various weeds including Parthenium. Large scale utilization of weeds can be an attractive alternative to economically signify as well as manage hazardous weeds (Javaid and S. Shafique, 2010) .

Management of Parthenium by Utilization

Biochar Preparation. Biochar has been formulated successfully from *Parthenium hysterophorus* by its pyrolysis to sequester carbon for negative carbon dioxide emission (Kumar *et al.*, 2013). Addition of this biochar to the soil improved soil quality as evidenced by increased growth of *Zea mays*, increased basal respiration and microbial biomass carbon, increased catalase and dehydrogenase activities, and decreased soil stress and hydrolytic enzymes activities. During charring, ambrosin chemical present in *Parthenium*, having phototoxic effect was lost by degradation at

high temperature. Adding large amounts of biochar did not show any negative effect on soil (Patel *et al.*, 2011).

Dye Degradation: have used leaves of fast growing *Parthenium* for extracting plant phenoloxidase enzyme having ability to degrade various aromatic rings in dyes. Concentrated enzyme showed rapid degradation of Yellow 5G and Brown R dyes present in golden colour imparting indanthrene formulation using free oxygen. Toxic effects in treated water were also minimized as indicated by survival of test bacteria, *E. coli* and *S. aureus*. (Shinde *et al.*, 2011)

Biogas Production: *Parthenium hysterophorus* as an additive (10%) in cattle manure and achieved 60–70% CH₄ production, suggesting potential of *Parthenium* weed as a substrate for biogas production. Subsequently Gunaseelan successfully produced 75% methane per kg biomass from *Parthenium hysterophorus* alone. Alkali pretreatment of *Parthenium* has been documented to increase biogas production than untreated biomass. During the process of biogas production, degradation of phytotoxic allelochemicals has been seen (Nallathambi Gunaseelan, 1998). Various inocula have been tested in differing ratios for maximizing yield of methane. Readily available sugarcane press mud cake mixed with cow dung augmented methane production from *Parthenium* (Thakur *et al.*, 2000). Careful monitoring of anaerobic digestion of the weed showed maximum methane formation only after 45 days, with decreasing pH and C :N ratio becoming constant after 45 days. These results were reproduced by Thakur and Singh, while also using other weeds and agricultural wastes for biogas production. Biogas has also been produced from mixture of cow dung and *Parthenium* (Kannan *et al.*, 2003). Reduction in C :N ratio was suggested due to loss in organic carbon in CH₄ and CO₂ formation and accumulation of hydrolyzed nitrogen in the slurry. Addition of *Parthenium* leachate, obtained by soaking plant in water for one week, to cow dung boosted biogas production from cow dung (Gitanjali *et al.*, 2009) while slurry left could be used as manure.

Composting. Composting of *Parthenium hysterophorus* biomass has been done expeditiously. Compost derived from *Parthenium* contains plenty of micronutrients such as Fe, Zn, Mn, and Cu and macronutrients including NPK making it two times richer than farmyard manure (Channappagoudar *et al.*, 2007) Organic acids released during composting help

in liberation of insoluble K and increase the uptake of P and K (Murthy *et al.*, 2010). Compost also contains abundant enzymes. Though significant reduction in allelochemicals occurs during composting but better compost is obtained from plants in preinflorescence stage (Khaket *et al.*, 2012). Effect of compost has been intensified by addition of useful bacterial species *Azotobacter chroococcum* evidenced by increased productivity in wheat (Kishor *et al.*, 2010). One research study has reported production of improved compost (millicompost), with more nutrients and less allelochemicals, upon introduction of millipede *Harpaphe haydeniana* during composting (Aparva *et al.*, 2010).

Vermicomposting: According to the research study conducted by (Biradar and Patil 2001) *Parthenium* weed upon composting with *Eudrilus eugeniae* supports growth of worms, indicating potential of weed as good substrate for vermicomposting. This concept was confirmed by another study, showing increase in cocoon yield of earthworm, when *Parthenium hysterophorus* was vermicomposted in definite combination with cow dung. Vermicomposting with added *Parthenium*, promoting growth and germination in tomato seeds (Shobha *et al.*, 2012). *Parthenium* vermicomposted in its vegetative state produced manure with more N content whereas that produced from flowering stage had more P content (Saragthem *et al.*, 2009). Also manure obtained shows less toxicity (Rajiv *et al.* 2012) as allelochemical constituents such as parthenin and phenols are degraded during vermicomposting.

Role in Agriculture: Extracts are rich in allelochemicals, known for their bioherbicidal behaviour against other plants (Duke *et al.*, 2002, Hu *et al.*, 2013) which can be used in crucial agronomic manipulations such as weed control. Several reports supporting this finding include decreased seed germination of *Lepidium pinnatifidum* (Kishor *et al.*, 2010), *Eragrostis* by *Parthenium* extract, and reduction in weed density in rice fields manured with *Parthenium* biomass.

Green Manure. Another use of *Parthenium* in agriculture is exploiting its biomass for green manuring. Addition of *Parthenium* leaf manure to rice crop resulted in increased height of plants, increased yield of grains and straw, with no emergence of weed

in submerged conditions during rice cultivation (Javaid and Shafique 2009),(Saravanane *et al.*, 2012) . Maize growth was also enhanced by green manure from *Parthenium* An enhancement has also been noticed in growth of wheat plant when treated with *Parthenium* green manure (Javaid and shah 2010). It is advised to utilize this weed for manuring at pre flowering stage to avoid spread of weed through dissemination of seeds after seed setting in the plant. *Parthenium hysterophorus* showed high assimilation rate of nitrogen and phosphorus by maize crop. Thus this freely available weed can be utilized for enriching soil with manure, while replacing chemical fertilizers.

Pulp and Paper Making: *P. hysterophorus* represents rich source of lignocellulosic biomass. Chemical composition of *Parthenium* lignocelluloses has been reckoned as around 13– 17% lignin, 21% hemicelluloses, and 28% cellulose. It has been proved to be of a potential low cost and readily available raw material for manufacturing variety of papers with adequate strength and appropriate quality for various commercial applications (Naithani *et al.*, 2008, Shubhaneel *et al.*, 2013)

Cellulose Production: Water soluble α -cellulose can be produced using standardized methods from lignocellulosic substrates (Naithani *et al.*, 2008) which can be modified (esterified or etherified) variously to obtain derivatives such as carboxymethyl cellulose (CMC), cyanoethyl cellulose (CEC), hydroxymethyl cellulose (HMC), ethyl cellulose (EC), methyl cellulose (MC), hydroxyphenylmethyl cellulose (HPMC), and carboxymethylhydroxyethyl cellulose (CMHEC). These compounds have wide variety of applications as additives in chemicals used in textile, paint, pharmaceutical, cosmetic, food, adhesives, and packaging industries. *P. hysterophorus*, being an annual plant having more cellulose, has been suggested as a good candidate for producing α - cellulose.

Corrosion Inhibition: Crude extract from leaves of *P. hysterophorus* suppressed corrosion of steel in acidic conditions. Water was used for extract preparation to avoid toxins, which are more soluble in organic solvents (Ji *et al.*, 2012).

Effect on Other Weeds: Extracts from *Parthenium* plant parts have been recorded to show inhibitory effect towards *Eragrostis* and common aquatic weeds, the water hyacinth (Pandey *et al.*, 1994), and *Salvinia*.

Among various parts, flowers and leaves are the richest in allelochemicals and can kill water hyacinth plant in one month. On the other hand, stem and root parts containing lower phenolics concentrations have been found to show nutritive properties supporting growth of the weed. Therefore, appropriate parts and dose of *Parthenium* plant can be used effectively to control certain weeds.

Feed Additive for Silkworm. Larvae of phytophagous insect, *Bombyx mori* L., a silkworm, have been found to be tolerant to pure parthenin, toxic for most of the other insects. Feeding these larvae on a diet supplemented with *Parthenium* root extract showed increased cocoon yield and hence silk production (Chanderkala *et al.*, 2013).

Synthesis of Nanoparticles: Another use of *Parthenium* weed exposed in recent years is use of its extract for synthesising silver nanoparticles (Parashar *et al* 2009., Mangrola *et al* 2012, Aananda *et al* 2012, Kumar *et al* 2013) and zinc oxide nanoparticles (Rajiv *et al.*, 2013) having reasonable stability. Nanoparticles synthesized by this method inhibited the growth of potent bacterial pathogens such as *E. coli*, *Pseudomonas putida*, *Klebsiella pneumoniae*, *Staphylococcus aureus*, *Salmonella typhi*, *Pseudomonas aeruginosa*, *Proteus vulgaris*, and *Bacillus subtilis* (Aananda *et al.*, 2012,) Zinc oxide nanoparticles were also found effective against pathogenic fungi.

Bioethanol Production: *Parthenium* weed species growing exuberantly and difficult to manage can be an attractive substrate for producing second generation biofuels (Chatterjee, 2012) Several other studies have indicated release of large amounts of total reducing sugars upon saccharification of *Parthenium* biomass delignified with lignolytic fungi such as *M. Palmivorus*, Pandiyan *et al.*, 2014 and *Trametes hirsute*.

Bioadsorption: Research efforts are in progress worldwide to find novel and efficient bioadsorbents for removal of industrially generated harmful pollutants. *Parthenium* has been proposed as low cost substrate for use as adsorbent (Sangita and Bute 2009).

Phytoextraction: has been found to play vital role in accumulation of heavy metals especially in contaminates sites (Mane *et al.*, 2013).

Other Uses: Possible utilities of *Parthenium* plant have been depicted. The weed can be managed by utilization in any of these ways. For example, the lignocellulosic rich waste, generated after extracting plant enzyme or separation of useful plant extracts, can be employed for other usages associated with lignocelluloses. Also the waste left after production of biogas, biofuel, pulp and paper, and celluloses can be utilized for manure formation. The multiple integrated utilizations of weed can prove an effective strategy for its control with an additional advantage of generating nearly zero waste at the end.

CONCLUSION

The allelopathic nature of *Parthenium hysterophorus* is attributed to its greater adaptability to diverse ecological niches, high fecundity, high regenerative potential, production of allelochemicals and repulsion to herbivores, and so forth. Established chemical and nonchemical methods of management of *Parthenium* weed show limited success in controlling this unmanageable weed. This necessitates the development of new strategies for the management of *Parthenium*. Novelty is desired in new methods in terms of their eco-friendliness and economic significance. Abundance of *Parthenium* weed in abandoned land accounts for its easy procurement as low cost material for various purposes. The weed can be used on a large scale for various applications. Nutritionally rich compost can be obtained from the weed by composting it formally or by using techniques of vermicomposting, which can be employed for increasing productivity of wide variety of agriculturally important crops. Practice of green manuring utilizing *Parthenium* weed has also proved an effective tool for raising fertility of cultivated land soil. The proposed usefulness of *Parthenium* in agriculture has been demonstrated by several research activities. The lignocelluloses rich biomass of weed plant can be exploited in recent energy conserving strategies of biofuel and biogas formation.

It can also be used as low cost substrate for other cellulose based applications, that is, production of cellulose, oxalic acid, xylanase, and pulp or paper. Potential of *Parthenium* has also been traced in phytoextraction of heavy metals, bioadsorption of pollutants, dye degradation, biochar preparation, corrosion inhibition, and inhibition of other weeds, which suggests diverse ways of utilization of this

weed. Role of *Parthenium* discovered in nanotechnology presents new ways of using this weed. Capability of weed to function as a source of dye, edible protein, spices, feed additive, and animal feed after ensilage opens more directions for utilization of this weed. Multitudes of chemotherapeutic and curative uses of *Parthenium* should be expanded further to broaden the utilization scope of the weed.

Also the research work dedicated to one particular application is very restricted and needs elaborative studies. Such methods can also be designed in future, which integrate two or more applications, aiming at maximum utilization of weed for acquiring economic benefits. Zero waste technology, being followed these days, can also be taken into account while shaping these integrated approaches. Thus new and improved methods of managing *Parthenium hysterophorus* weed, encouraging well-being of human society, are anticipated in near future.

Conflict of Interest

The author declares that there is no conflict of interest.

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