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Research Article

SUSTAINABLE UTILIZATION OF PARTHENIUM WEED FOR PRODUCTION OF BIOCHAR AND ENVIRONMENTAL MANAGEMENT

Gaddeyya Gandipilli and Esteru Rani Geddada

Centre of Advanced Study, Department of Botany, Andhra University
Visakhapatnam, Andhra Pradesh-530003

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ABSTRACT

Parthenium hysterophorus Linn. (Asteraceae) considered a serious weed in several tropical and subtropical countries across the world is supposed to have originated in North East Maxico. The weed shows a drastic impact on other plants as a strong competitor and creates health hazards in humans and animals. It is an aggressive invasive weed, threatening natural ecosystems and agroecosystems in over 30 countries worldwide. Parthenium weed causes losses of crops and pastures, degrading the biodiversity of natural plant communities. Various management approaches (namely cultural, mechanical, chemical and biological control) have been used to minimise losses caused by this weed, but most of these approaches are ineffective and uneconomical and/or have limitations. Although chemical control using herbicides and biological control utilising exotic insects (*Zygogramma bicolorata* Pallister) and pathogens (*Puccinia abrupta* var. *partheniicola*) have been found to contribute to the management of the weed, the weed nevertheless remains a significant problem. The weed utility approach is proposed here for the effective management of parthenium weed on a sustainable basis.

INTRODUCTION

Parthenium hysterophorus L., is a weed of world significance. It is most popularly known as congress grass, gajarghas, and carrot grass in India. It is one of the most aggressive herbaceous weeds of the family Asteraceae. *Parthenium* is native to the area surrounding the Gulf of Mexico, Central America, Southern North America, West Indies, and Central South America (Navie 2003). The spread and infestation of *Parthenium* are severe in some of the countries like Australia, South Africa, Ethiopia, India and Pakistan. In India, the weed is a serious problem in states like Andhra Pradesh, Bihar, Haryana, Karnataka and Madhya Pradesh (Sushilkumar, 2014). It is an annual short lived herbaceous plant that invades preferably vacant land, disturbed sites, road sides, railway tracks sides, wastelands, water courses, agricultural crops *etc*. It degrades natural ecosystems by reducing biodiversity (Holm *et al*. 1997) and can cause serious allergic reactions in man and animals (Lonkar *et al*. 1974, Chippendale and Panetta 1994).

Parthenium is responsible for huge losses to the biodiversity, agriculture, economy, and health of livestock and human beings and it was considered as one of the world's most dangerous weeds. High competitive success rate, high seed production (Fig 1) and germination and the adaptability of the species enable it to dominate diverse types of habitats such as barren areas, road and railway tracks, and crop fields. Various weed control strategies (mechanical, cultural, herbicidal and biocontrol) are being used globally to reduce its population to manageable levels. But owing to many limitations associated with these conventional methods management of *Parthenium* still remains a challenge. 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 such as production of green manure or compost, Industrial products (biochar, biofuel and soil amendment mixtures), drugs and bioactive principles. This weed also exhibits many environmental applications. The large scale utilization of *Parthenium* may also be one of the effective methods to manage the weed besides mechanical and biological control. Keeping in view the huge green and dry biomass of *Parthenium*, available in India and other countries, there is need to sustainable utilization and management of *Parthenium* weed.

Corresponding author:* **Gaddeyya Gandipilli
Centre of Advanced Study, Department of Botany, Andhra University Visakhapatnam, Andhra Pradesh-530003

Biochar from Parthenium weed

Biochar is a fine-grained, highly porous charcoal that helps soils retain nutrients and water. As a soil amendment, biochar helps to improve the Earth's soil resources by increasing crop yields and productivity, by reducing soil acidity, and by reducing the need for some chemical and fertilizer inputs. (Glaser *et al*. 2007). Water quality is improved by the use of biochar as a soil amendment, because biochar aids in soil retention of nutrients and agrochemicals for plant and crop utilization (Lehmann *et al*. 2003). Biochar can be 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 results 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 a chemical present in *Parthenium*, having phototoxic effect was lost by degradation at high temperature (Patel, 2011). Adding large amounts of biochar did not show any negative effect on soil.

The ancient method for producing biochar as a soil additive was the "pit" or "trench" method, which created terra preta, or dark soil. While this method is still a potential to produce biochar in rural areas, it does not allow the harvest of either the bio-oil or syngas. Biochar production processes can utilize most urban, agricultural or forestry biomass residues. Modern method biochar production is sought in pyrolysis. This is done on either small or large scale. The small scale production allows subsistence farmers to produce small quantities of biochar usable for their farms or garden. Pyrolysis is a form of incineration that chemically decomposes organic materials by heat in the absence of oxygen. Pyrolysis typically occurs under pressure and at operating temperatures above 430 °C (800 °F). The yield of products from pyrolysis varies heavily with temperature. The lower the temperature, the more char is created per unit biomass. High temperature pyrolysis is also known as gasification, and produces primarily syngas from the biomass. The two main methods of pyrolysis are "fast" pyrolysis and "slow" pyrolysis. Fast pyrolysis yields 60% bio-oil, 20% biochar, and 20% syngas, and can be done in seconds, whereas slow pyrolysis can be optimized to produce substantially more char (~50%), but takes on the order of hours to complete. In the process of pyrolysis, biomass tends to undergo structural transformations leading to the formation of stable aromatic rings. The pyrolysis process parameters like temperature and residential time will greatly affect the qualities of biochar and its potential value to agriculture. *Parthenium* biomass charred at different temperature (200-500 ˚C) and residence time (30-120 min) yield the biochar. This low temperature pyrolysis condition is good enough for the preparation of stable Parthenium Biochar (PBC) for soil application.

Biochar for soil and environmental management

The term 'biochar' is a relatively recent development, emerging in conjunction with soil management and carbon sequestration issues. Biochar is the carbon-rich product obtained when biomass, such as wood, manure or leaves, is heated in a closed container with little or no available air. In more technical terms, biochar is produced by so-called thermal decomposition of organic material under limited supply of oxygen (O_2), and at relatively low temperatures (<700°C). Biochar is produced with the intent to be applied to soil as a means of improving soil productivity, carbon (C) storage, or filtration of percolating soil water. In contrast to the organic C-rich biochar, burning biomass in a fire creates ash, which mainly contains minerals such as calcium (Ca) or magnesium (Mg) and inorganic carbonates. Both research and development of biochar for environmental management at a global scale is a future prospect. Biochar acts as a sponge in the soil, absorbing and retaining water, gases and solutions. Biochar is not merely another type of compost or manure that improves soil properties, but is much more efficient at enhancing soil quality than any other organic soil amendment.

Besides carbon sequestration the biochar production technology should be useful for the environmental management with some specific objectives include Soil improvement, waste management; climate change mitigation and Energy production. Biochar provides a unique opportunity to improve soil fertility and nutrient-use efficiency using locally available and renewable materials in a sustainable way. Adoption of biochar management does not require new resources, but makes more efficient and more environmentally conscious use of existing resources. Managing weed biomass poses a significant environmentally holistic approach. In addition, appropriate management of organic wastes can help in the mitigation of climate change indirectly by reducing industrial energy use and emissions due to recycling and waste reduction. During pyrolysis of biochar, the bioenergy produced as by-product may contribute significantly to securing a future supply of green energy. A main benefit may be that pyrolysis offers clean heat, which is needed to develop cooking technology with lower indoor pollution by smoke than is typically generated during the burning of biomass. Adding biochar to soils has been described as a means of sequestering atmospheric carbon dioxide to reduce atmospheric CO_2. Adopting biochar-based strategies for energy production, soil management and C -sequestration relies primarily on individual companies, municipalities and farmers, governments and international organizations. In addition to this, biochar sequestration, in combination with sustainable biomass production, can be carbon-negative and therefore used to actively remove carbon dioxide from the atmosphere, with potentially major implications for mitigation of climate change. Biochar production can also be combined with bioenergy production through the use of the gases that are given off in the pyrolysis process.

Outcome of the study

The following aspects are the major outcomes of the study:

Benefits to the agricultural sector

- Improve nutrient retention and carbon storage for soil health.
- Improve crop productivity
- The biochar production process transforms waste into useful resource

Benefits to industrial sector

- Small-scale and large scale production of biochar
- Biofuel and other by-products act as sustainable renewable energy sources
- Bio Oil- can be used as a substitute for diesel in some engines.
- The pyrolysis process can be used to create the electricity

Climate change mitigation

- The storage of carbon over long periods
- Biochar capture terrestrial carbon (reduction of greenhouse gases)
- Recycling and production of renewable energy

Figure 1 *Parthenium hysterophorus* weed plant with flowering

Summary

Parthenium hysterophorus L., (Asteraceae) is one of the world's seven most devastating and hazardous weeds. Though there are many traditional weed control measures, the utilization of *Parthenium* is affective and eco-friendly approach. Besides soil carbon sequestration, thermal conversion of *Parthenium* to biochar would be a sustainable weed management strategy. The present study is hypothesized that pyrolytic conversion of *Parthenium* to biochar (BC) could be an alternative option for weed control.

Biochar is a fine-grained charcoal produced from plant biomass from pyrolysis, the slow burning of organic matter in a low- or no-oxygen environment. Thermo-chemical processes like combustion, pyrolysis, and gasification have wide application to convert bulky and heterogeneous biomass into useful forms such as biochar and biofuel. Biochar is the carbonaceous residue left in the pyrolysis process, which is recently being recognized as an interesting material to store carbon in soils and to improve soil fertility.

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