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Role of Allelopathy for Suppression of *Parthenium hysterophorus*: A Review

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Abstract

Gajjar grass, *Parthenium hysterophorus* L., from the family Asteraceae (tribe: Heliantheae), is a vertical and densely branched annual herb well-known for its environmental, medical, and agricultural hazard. It is thought to have been familiarized into India and Australia from North America and in the previous few years the weed has appeared as the utmost distressing weed in Africa, Asia, and Australia. Many scientists employed biological methods like insects, fungi, trees and crop plants which were creating harm to *P. hysterphorus*, but found the allelopathy as the most efficient method to control the parthenium as well as other weeds. Scientists are doing experiments to use allelopathic potential of plants for weed management. It has been shown in researches that the extracts and residues of many allelopathic plant species (herbs, grasses and trees) effectively reduce the germination and growth of parthenium. The purpose of this review is to summarize all the general information about biological management of this noxious weed. Parthenium control has been attempted using a variety of methods, but no sole administration choice would be suitable to cope Parthenium, and there is a need to assimilate numerous management choices. The only way to successfully manage this weed is through a comprehensive mechanism that includes bio-control as a major component.

Keywords

Parthenium, Allelopathy, Suppression, Weed Management

1. Introduction

Parthenium weed (*Parthenium hysterophorus* L.) is a herbaceous annual plant that is invasive [1]. It is a member of Asteraceae family and is usually known as Parthenium weed [2, 3]. Parthenium weed plant is characterized by deep tap root system, light green leaves and a vertical stem that becomes woody with the time [4]. According to a study by Navie, PANETTA [5], when grown in suitable soil, Parthenium can achieve a height of 2 m and flower within the first four to six weeks of germination. This noxious invader, which originated in the north Americas, has now infested more than forty countries worldwide, including Africa, Asia, the Pacific, and Australia [6]. Parthenium weed is spreading rapidly in Pakistan's lands and along roadsides. It is well adapted to semi-arid environments due to its unique abilities like huge and persistent soil seed bank, rapid germination rate, and ability to undergo dormancy. It also emits chemicals that prevent pasture grasses and other plants from germinating and growing [7]. It is a main weed in crop fields and grasslands, acting as a substitute host to numerous major crop pests, has a negative impact on the diversity of native plant species in a variety of environments, causes toxicity issues in livestock and significant health issues in humans [8]. Its aggressive nature is obvious from its capability to form vast mono-cultural positions with no other plant in the locality as shown in

figure: 1. It causes various of environmental and agricultural issues (reduction in crop productivity, scarcity of fodder, depletion of biodiversity) and also many health problems for human beings and livestock [9]. In an artificial feeding test, buffalo and bull calves accepted the weed, either alone or mixed with green fodder, with disastrous results. The bulls and calves developed severe dermatitis & venomous indications and died within period of 8-30 days. Lesions were later discovered in the gastro-intestinal tract, liver, and kidneys [10]. Some chemical herbicides offer actual control of this species. Though, weeds infestation on a large scale is creating major environmental concerns, because of continuous and frequent use of chemicals. More Sustainable and Ecologically viable approaches have been proposed to manage this species [11]. One of the most successful biological control agent involved in bio-management of Parthenium is the leaves-feeding beetle (Zygogramma bicolorata Pallister; Coleoptera: Chrysomelidae). Although this bio-control agent has spread widely within the Parthenium weed infestation range, but not providing effective control on its own [12]. Figure 1 illustrates the seed dispersal and life cycle of *Parthenium hysterophorus.* Keeping in view the noxiousness and aggressiveness of *Parthenium hysterophorus* following allelopathic methods have been found successful to control this weed. This review will summarize all the possible allelopathic controls of *Parthenium hysterophorus.*

2. Impact of Parthenium on Agriculture

- *Parthenium hysterophorus* aggressively colonizes 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, Actinomycetes, Azotobactor and Azospirillum.
- 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.
- Parthenium weed seed is also a contaminant of grain, pasture and forage seeds. Hence, it results in restricted sale and movement of these produces

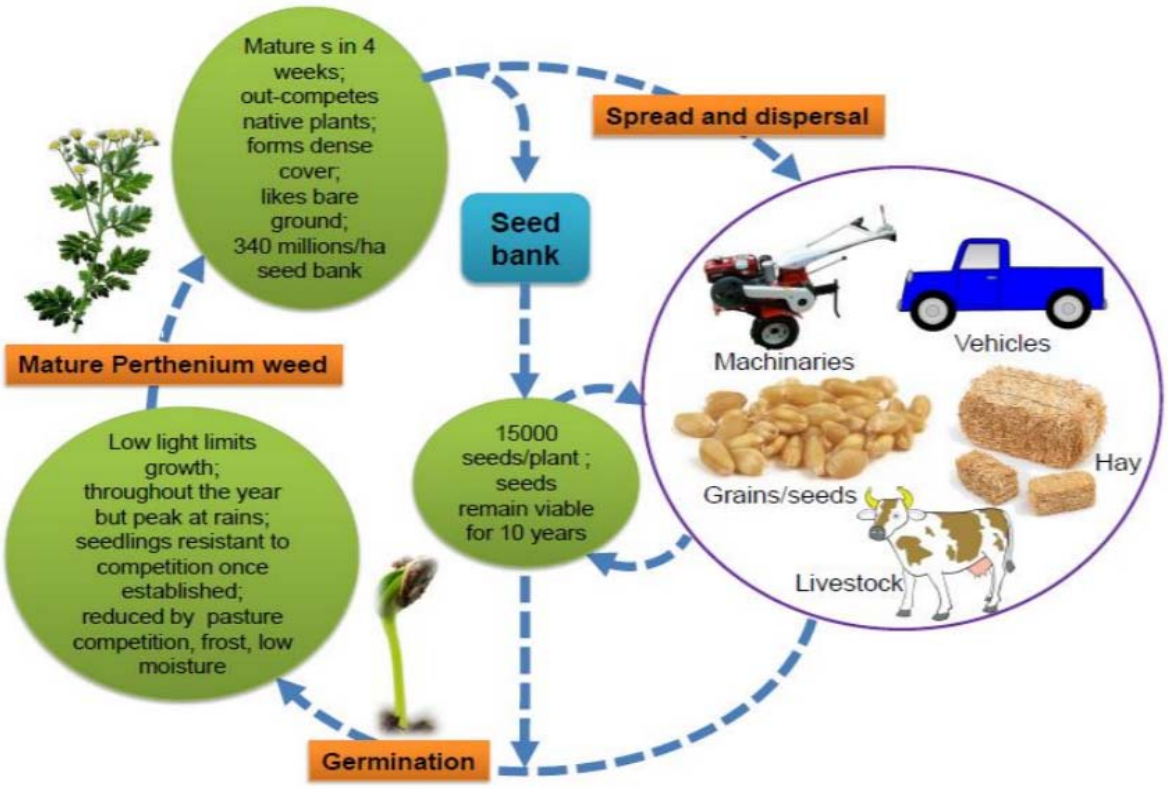

Figure 1. The seed dispersal and life cycle of *Parthenium hysterophorus* [13].

3. Allelopathic Suppression of Parthenium

The word "Allelopathy" was proposed by Molisch (1937), which refers about the deleterious consequences of a plant species on seed sprouting, progression, and reproduction of another plant species. Various plants are proposed to ha-

veallelopathic prospective and struggles are being made to practice them in weed control [14]. Planting plants such as *Cassia sericea*, *C. tora*, and *C. auriculata* can help to replace parthenium in a competitive manner [15, 16], *Amaranthus spinosus*, *Tephrosia purpurea*, *Croton bonplandianum*, *Sidaspinosa*, and *Mirabilis jalapa*, *Hyptis suaveolens* [17] which are able in suppressing Parthenium effectively in natural habitats [16]. According to one study, Cassia sericea diminishes parthenium accumulation by 70% and parthenium population by 52.5 percent [18].

4. Suppression by Trees

Aqueous leaf extracts of Alstonia scholaris (L.) R. Br. inhibited the germination and growth of parthenium as shown in Table 1 [19]. Its leaves contains many indole alkaloids [19,20-(E)-vallesamine, angustilobine B N4-oxide, 20(S)-tubotaiwine, 5-epi-nareline ethyl ether and 6,7-seco-angustilobine B] [20], which may be responsible for the herbicidal activity of its aqueous extracts. The deleterious effect of eucalyptus oils extracted from *Eucalyptus glohulus* and *Eucalptus citriodora* on *P. hysterophotus* was reported by [21]. Table 1 shows the researches done on the allelopathic control of parthenium using extracts of different trees. The chlorophyll content and cellular respiration of the mature plants of Parthenium were drastically reduced when exposed to eucalyptus oils and the germination of the weed was inhibited as well. In addition, after 15 days of exposure to volatile oils, an increased water loss in the treated plants was recorded that resulted in complete wilting of the plants [22]. An experiment using leaves, shoots and roots extract of four tree species (Albizia gummifera, Azadirachta indica, Melia azedarach, Sesbania sesban) was conducted in green house and laboratory conditions which showed suppression of Parthenium seed germination and also it inhibited the growth of Prathenium seedling [23]. Shafique, Bajwa [24] assessed the herbicidal activity of aqueous extracts (2, 4, 6, 8, 10%) of dry leaves of *Ficus bengalensis L.*, *Azadirachta indica (L.*) *A. Juss*, *Melia azadarach L.*, *Mangifera indica* L. and *Syzygium cumini (L.)* Skeels against parthenium seeds germination in lab bioassays. The 8% and 10% extracts of these tree species significantly suppressed the germination of parthenium seeds.

Table 1. A summary of different experiments conducted to control Parthenium by using Allelopathic potential of trees

Tree Specie	Part of Plant used in Study	Allelochemicals available	Suppression/Inhibitory effect	Reference
Alstonia scholaris	Leaves	indole alkaloids (19,20(E)-vallesamine, angustilobine-B N_4oxide, 20(S)tubotaiwine, 5-epinareline ethyl ether and 6,7-seco-angustilobine B)	Reduced Plant Growth and Germination of seed.	[25]; [26].
Eucalyptus citridora	Leaves and Branches	Phenolic acids, tannins, flavonides, and eucalypt oils	Reduced Plant Growth and Germination of seed.	[22]; [27]
Eucalyptus globulus	Leaves and Branches	Monoterpenes (cineole, citronellol, citronellal and linalool),	Reduced Plant Growth and Germination of seed.	[28]; [27]
Azadirachta indica	Leaves	Gallic,benzoic, p-coumaric, p-hydroxybenzoic, vanillic, and transcinamic acid	Reduced Germination of seed.	[29]; [30]

5. Suppression by Agronomic Crops

Many Crops have been reported suppressing the germination and growth of Parthenium by their alelopathic actions.

Rice: Rice (*Oryza sativa L.*) is a well-known allelopathic crop [31-33]. Its aqueous root and shoot extracts reduces the germination and root growth of parthenium weed [31, 34]. Different rice varieties exhibit variable phytotoxic effects against germination and growth of parthenium [35]. Similar to that of rice extracts, incorporation of rice residue also reduced the germination and growth of parthenium [32]. The living and dead rice plants release different allelochemicals. Allelochemicals from living rice plants are: Momilactones A and B, 3-isopropyl-5-acetoxycyclohexene-2-one-1 and 5,7,4'-trihydroxy- 3",5"-dimethoxyflavone [36]. Allelochemicals from rice residues are: Momilactone B and phenolic acids (phydroxybenzoic, p-coumaric, ferulic, syringic and vanillic acids) [33].

6. Sorghum and Sunflower

The shoot and root extracts (5-25%) of sunflower (*Helianthus annuus L.*) and Sorghum (*Sorghum bicolor L.*) significantly reduce the germination potential and growth of root in parthenium plant [31]. Several phenols and terpenoides

(7,11-heliannane, annuolide E, leptocarpin, annuionone E [37], heliannuol L, helibisabonol A and helibisabonol B have been reported as potential allelochemicals in various cultivars of sunflower [38]. Sorgoleone [39] exuded from the sorghum roots [40] suppresses the growth of weeds [41-42].

7. Conclusion

The *Parthenium hysterophorus* has ability to grow in a wide range of habitats and induces major shift in the type of vegetation in its surroundings and also cause depletion in soil nutrients. It can displace many important plants with medicinal and nutritional importance in its surroundings. To eliminate the possible hazards to the biodiversity and possible economic losses appropriate management approaches for *Parthenium hysterophorus* are much required. Most cost effective and time efficient methods proposed for the management of this weed is biological control involving allelopathic approaches. There is a huge room for further research on *Parthenium hysterophorus* because it is spreading rapidly and causing nuisance in developing countries like Pakistan and all this can be done by combined efforts of farming community, researchers and Government.

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