



Research Article

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Threats and Management Options of *Parthenium* (*Parthenium hysterophorus* L.) in Ethiopia



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Abstract

Parthenium (*Parthenium hysterophorus* L.) is one of the invasive weed invading the natural environments globally. These weed can tolerate wide ecological range; occur in diverse habitat, on wide range of soils and grow throughout the year provided adequate moisture, temperature and sunlight are available. A large area in Ethiopia has also been invaded and invasions by these weed are expected to change the natural diversity and balance of ecological communities in the country. Before encroaching onto native vegetation, these aggressive environmental weed generally takeover disturbed areas. Thus the survival of many indigenous plants may be threatened. Apart from this these alien weed species can disrupt waterways, produce allergies, adversely affect human and animal health, livestock production and reduce aesthetic values. This weed is capable in displacing desirable species in many habitats and disturbed forests due to allelopathic qualities which can reduce germination and vigour of neighboring plants. Their establishment in pasture-and grazing-lands out-competes the valuable plant species for livestock. *Parthenium* can cause heavy yield reductions in many crops. Therefore, these weed is increasingly seen as a threat not only to biodiversity and ecosystem services, but also to economic development and human comforts. Physical, herbicidal and cultural methods may have scope limited only in crop fields, orchards, tea and coffee plantations. Therefore, sustainable long term management strategies should include prevention, use of replacement competitive plants in newly infested and insect bio-agents in severely infested areas. In grazing- and pasture-lands as well as in low infested forests and non-crop areas, integrated use of herbicides as well as rehabilitation with useful plant species has to be developed. To contain the further spread and soil seed bank buildup for future infestation these weeds should be utilized for mulching, composting, residue incorporation in crop fields and production of biogas etc. Besides, extensive mass awareness and community campaign especially to uproot *parthenium* and its safe disposal among the stakeholders needs be conducted.

Keywords: Allelopathic; Competitive plants; Ecosystem; Habitat; Insect bio agents; *Parthenium*

Introduction

Invasive weeds are one of the major threats to the natural environment. They destroy native habitats; threaten native biodiversity therefore, the survival of many plants and animals. Major weed invasions change the natural diversity and balance of ecological communities. The weeds compete with native plants for space, nutrients, moisture and sunlight. Weeds invade crops, smother pastures reduce farm and forest productivity. The weeds can also be menace to human and livestock health thus, can result in reduction of human and animal efficiency. *Parthenium* (*Parthenium hysterophorus* L.) is among some of the most invasive weed in Ethiopia. The invasion by these plant species is being seen as a threat not only to biodiversity and ecosystem but also to human welfare.

Parthenium weed is an annual herb in the family *Asteraceae* which is characterized by deep tap root, pale green leaves and an

erect stem that becomes woody gradually. At maturity, the plant develops several branches in its top half and may finally reach a height of 1.5-2 meters [1]. It is originated in northern Mexico and southern USA, and spreading in more than 20 countries of Africa, Asia and Oceania [1].

Parthenium was probably introduced to Ethiopia through army vehicle during 1976 Ethio-Somalian war or along with contaminated grain in the course of food aid [2,3]. However, Wise et al. [4] reported *Parthenium* was first recorded in Ethiopia at the Haramaya University campus in 1968. Since its introduction the weed has rapidly spread throughout agricultural lands, forests, orchards, poorly managed arable crop lands and rangelands in Ethiopia [2,5].

In the presence of *Parthenium* the growth and development of crops can be suppressed, and if not controlled on time, it will

occupy the land alone. Due to its Aggressive coverage, Oromia region farmers call it 'Anamalee,' in Afaan Oromo-meaning 'Only me'. Ayele et al. [6] reported species richness and evenness indices of both the above ground vegetation and the soil seed bank significantly decreased at the high level of *Parthenium* weed infestation and that the decline in species heterogeneity could be due to the strong allelopathic effect of *Parthenium* and/or competition for common resources and thus, suppress the performance of the neighboring plant species. Similarly, Kumari et al. [7] reported that *Parthenium* weed has the capacity to overwhelm the surrounding weed species and it could absolutely dominate the area inhabits and finally leads to loss of bio diversity. According to O'Donnelli and Adkins [8] *Parthenium* affects agricultural and natural ecosystem production and biodiversity, and on human and animal health. Mirza et al. [9] also said the damage of this weed does not end up with direct competition but also the reduction of the quantity and quality of a crop produced through allelopathic effect.

According to Rezene et al. [10], *Parthenium hysterophorus* is spreading rapidly in various rangeland areas and farm lands of Gambella, Oromia, Afar, Amhara and Somali, Southern nations and nationalities regional states which affecting crop production severely. Hadas & Taye [11] reported its distribution in to Tigray region particularly, Waja, Alamta town, Bala, kukufto, Zata, Weyrawiha, Bedenoleka, Mohoni town, Maichew town, Kisad Gudo, Adishu, Adigura and Adigudom). It is found in all the Districts but more prominent in Alamata and Raya Azebo. According to the study conducted by Taye [12] extensive infestation in the central farmlands of east Shewa, Dukem, Bishoftu, Modjo and Koka areas has been prevailed. Gebrehiwot & Berhanu [13] reported that there has been an urgent need towards the management of *Parthenium* weed in Arba Minch, before it further spread to Nech Sar National Park, which is a home of plants' diversity. Zuberi et al. [14] informed that *P. hysterophorus* is spreading rapidly in the highlands of Ethiopia.

The distribution and spread of *Parthenium* showed that it was not only restricted to the infested Districts but also spread to non-infested Districts like Arero, Bore, Dama and Uruga Districts of Borana and Guji Zones. It is found in Abaya occasionally, present in Bule Hora, abundant in Dugda Dawa, very abundant in Yabello, present in Teltele, frequent in Dire on roadsides, present in Miyo and Moyale, very abundant in Liben, present in Wadera, Adola and Shakiso Districts [15]. *Parthenium* is widely spread in the range lands and in the cultivable fields of East Showa Zone of Boset district [16].

A study by Ayana et al. [17] in Awash National Park (Ethiopia) showed that *Parthenium* weed, within a few years from its introduction into Awash National Park, caused a decline (average 69%) in stand density of herbaceous species. Similarly, Asresie [18] pointed out that an increase in the level of *Parthenium* infestation causing rapid decline in the population and diversity of species in the ecosystem.

The impact of *Parthenium* on the yield losses of various crops and orchards has been addressed in the report of earlier works. Crop losses are caused mainly due to allelopathic effects and its ability to compete for common resources like nutrients and moisture and its competitive nature is relatively very much higher than expected from a similar crop weed. Another mechanism by which *Parthenium* affect crop productivity is through its ability to cover crops in pollen, which prevents seed set with resulting losses in yields of up to 40% [4]. *Parthenium* weed can infest the land where cereals, vegetables and horticultural crops found and reduce agricultural productivity due to its allelopathic effect [19]. The decline in yield due to its highly competitive ability was also reported by Netsere & Mendesil [20]. Tamado et al. [21] reported that if *P. hysterophorus* is not weeded throughout the season the yield of sorghum bicolor can be reduced in the range of 40% and 90% in Ethiopia, this percentage was closer to the report of Wise et al. [4], which was range from 45-80%. According to Nganthoi et al. [22] there was a visible impact on the growth parameters, yield and yield components of *Zea mays* by *Parthenium*. Accordingly, at high ratio (20:1) population of *Parthenium* the plant height, dry biomass, corn weight, corn length and grain weight per corn were reduced to 21.1%, 42.3%, 50.9%, 51.2%, and 52.7% respectively as compared to control. Furthermore, the finding indicate *Parthenium* in the form of extract or residue or growing weed can affect the germination and growth by reducing radicle and plumule length of *Zea mays*. Tefera [5], also reported that 10% leaf aqueous extract of *Parthenium hysterophorus* resulted in total failure of seed germination in *Eragostis tef*. Similarly, Demissie et al. found the presence of allelopathic effect in *Parthenium* extracts which could affect the seed germination and elongation of Onion and Bean. Dangwal et al. [23] investigated that while primary major essential nutrients (NPK fertilizer) supplied, but in the absence of herbicide application and mechanical weeding, *Parthenium* weed along with other weeds were reduced the yield of wheat by 25.35%. Besides reducing the yield they also reduce the quality of germplasm of wheat crop. Raj & Jha [24] disclosed that higher concentrations of leaf extract have irregularly affected the growth of *Phaseolus mungo* than lower concentrations.

Toxic substances found in *Parthenium* are lethal to human beings and animals [25]. It is considered to be a cause of allergic respiratory problems, contact dermatitis, mutagenicity in human and livestock. In addition, by reducing the species bio diversity it affect the productivity of grazing land and hence reduce feed supply for animals. It releases chemicals that inhibit the germination and growth of pasture grasses and other plants [26]. If *Parthenium* is eaten by animals, the meat gets polluted due to its toxicity problem and these result in direct economic losses. Thus, domestic animals should avoid eating it [4].

When human beings come in contact with this weed, it may cause allergy, dermatitis, eczema, black spots and blisters around eyes, burning rings and blisters over skin, redness of

skin and asthma [27]. *Parthenium* is spreading at alarming rate, threatening agricultural ecosystem, biodiversity, human and animal health in Ethiopia. The response of the 64 interviewed farmers in Ethiopia showed that all of them have health problems in different nuances. Most frequently they responded to *Parthenium* contact with light allergic symptoms like hay fever or skin prickle on arms and hands. Some farmers had worse health problems: cracks on hand balms, fever, prickle on the whole body, skin irritations, and asthma. In addition to parthenin high concentrations of phenolic acids which might also contribute to health problems [28]. Studies in Jijiga (Ethiopia) indicated that *Parthenium* causes asthma, bronchitis, dermatitis, and high fever in human [29].

Dispersal

With more vehicles on the roads, construction materials-soil and sand, dumping sites, contaminated food grains, fodder, nursery rootstocks, pasture and crop seeds [30], waterways, increased human and animal movements, travel and tourism, the seed dispersal has aggravated in the recent years. This weed is serious because of its biological attributes like high reproductive capacity, strong competitiveness, allelopathic effects, absence of natural enemies and the seeds can germinate any time of the year.

Threats

Parthenium is an aggressive pioneer that generally colonizes disturbed areas before encroaching onto native vegetation. In many introduced ranges *Parthenium* has posed serious threats to natural biodiversity, crop production, animal and human health because of prolific growth, rapid spreading and production of toxic allelochemicals [31-33]. The allelopathic effect, coupled with the absence of natural enemies like insects and diseases, is responsible for its rapid spread in introduced ranges and degrades natural ecosystems. *Parthenium* grows faster than native plants and successfully competes for available nutrients, water, space and sunlight and thus out competes native species; reduce natural diversity through smothering native plants. The major ecological and morphological characteristics that contribute to its severe invasiveness might be its adaptability to wide climatic and soil conditions. Currently, *Parthenium* is one of the noxious weeds threatening crop and livestock production and biodiversity in Ethiopia. The rapid spread of *Parthenium* in Ethiopia would be a bigger risk to the expansion and sustainable production of many crops, and development of tourism, human and animal health, and irreversible environmental and socio-economic impact.

Biodiversity

Parthenium colonizes disturbed sites very aggressively, impacting croplands, pastures. It generates allelopathic effects through root exudates and leaching, decaying plant residues into the soil. These secondary metabolites or allelochemicals-

inhibitors like lactones and phenols inhibit the germination and growth and yield of neighbouring plants. Similarly, in grasslands dominated by parthenium, native plant species composition and abundance was found to be low [34]. Thus, reduces growth and depresses forage production. *Parthenium* weed is a serious problem to natural plant communities [31,32]. Under the present scenario of squeezing grazinglands in the country and continued heavy grazing it is capable to exclude useful forage plants and can become dominant resulting in decreased pasture productivity, carrying capacity and land values. The studies conducted have depicted substantial decline in species richness and abundance. In a study conducted in rangelands of Mieso District, Ethiopia, *Parthenium* had 21.3% cover abundance value and 0.32 diversity index among broadleaved herbaceous weeds in. The major problem facing the pastoral production in Ethiopia is the wide scale degradation of native pasture encroachment. In Mieso and Talalak District (Afar) rangelands the highest relative density, relative frequency importance value and cover abundance was found for *Parthenium* among the herbaceous species [35,36].

Forest biodiversity is being reduced and the structure of many native plant communities are being altered [37,38] and problems are being created along water ways by *Parthenium* weed [31,39]. In Eastern Ethiopia, the biodiversity within some cropping and rangelands systems have also been severely reduced by *Parthenium* weed and other invasive weeds [40]. In sorghum fields *Parthenium* has adversely affected biodiversity by 20.9, 46.4 and 69.7 % at low, moderate and high infestation levels. The soil seed bank contained 64 and 59 % of the total seedlings germinated in sorghum fields and grazinglands, respectively [18]. More recently, *Parthenium* weed was reported to have seriously reduced biodiversity of pastoral lands in Ethiopia [41]. Research indicates that dense populations of *Parthenium* in native grassland can lead to significant decreases in the size of the native flora seed banks in many countries including Ethiopia [41-46]. Reductions in community biodiversity may lead to other serious community problems such as increased soil erosion and the extinction of certain native flora or fauna, prevention of both is important to the maintenance of a balanced ecosystem.

Agricultural production

The adverse impacts of *Parthenium* on agriculture have been reviewed by several authors [39,44,47,48]. In Ethiopia, sorghum grain yield was reduced between 40% and 97%, if the weed was left uncontrolled throughout the season [2] and 16.0-86.5 % in common bean [41]. It reduces pasture carrying capacity by up to 90% [10,49]. The quality of the produce is also eroded. On the other hand, *Parthenium* is known to have allelopathic inhibitory effect on germination and growth of many crops [50-52] and tea [53]. It generates allelopathic effects in the soils, and outcompetes crops for available nutrients and moisture, light and space. Its pollens are known to inhibit fruit set in many crops. It may have indirect effect on crop production due to host for many insect pest and diseases [48,54].

Human health

Parthenium causes health hazard to humans [55] and animals [31]. In human, the pollen grains, air borne pieces of dried plant materials and roots of *Parthenium* can cause allergy-type responses like hay fever, photodermatitis, asthma, skin rashes, peeling skin, puffy eyes, excessive water loss, swelling and itching of mouth and nose, constant cough, running nose and eczema [25,44,52,56]. In Ethiopia, people undertaking handweeding in *Parthenium* infested field suffer from skin diseases [57] and *Parthenium* related allergies can also bring on fever induced by malarial infection.

Animal health

All parts of the *Parthenium* plant at any stage of growth are toxic to humans and animals. The weed is toxic to domestic animals. Goats and sheep have been found frequently browsing the plant. However, leaves of parthenium, if eaten can result in tainted sheep and goat meat and make diary milk unpalatable due to its irritating odour [58]. It can also reduce milk yield. In animals, the plant can cause hair loss, eye irritation, skin lesions, anorexia, pruritus, alopecia, dermatitis and diarrhea, mouth ulcers with excessive salivation if eaten, and sometimes death due to rupturing and haemorrhaging of internal tissues and organs [59,60].

Aesthetic, recreation and other places

Infestation in national parks may adversely affect plant and wild animal biodiversity, tourism industry and industrial sites. The national parks in Kenya [61], India [62], South Africa [63] and in Ethiopia [17,64] have been encroached by the weed. Similarly in rural and urban areas the public parks and play grounds have been reduced in area.

Management of parthenium

Control of *Parthenium* is therefore, crucial not only to boost the productivity of crops but also to sustain livestock production and economic development in the country. Various approaches have been used worldwide to manage parthenium, but most of them have limited scope. Handweeding mostly used by small-scale farmers is more difficult due to the allergic effects of *Parthenium* on human body [18,35]. It is also costly in terms of labour and time requirement. The use of herbicides provides faster control [65,66] but often needs to be repeated on an annual basis such as when the weed reemerges from the soil seed bank. Chemical control is also considered to have a number of negative impacts including its high cost in vast area, possible negative impacts upon human and animal health, and environment besides repeated application of the same mode of herbicide action may lead to herbicide resistance development. Furthermore, resource poor farmers of Ethiopia may not afford the purchase of herbicides. Therefore, other options must be looked into for sustainable *Parthenium* management in the country.

Utilization

One of the possible options is to manage *Parthenium* through utilization. *Parthenium* can be utilized for the production of biogas, compost especially vermicompost and as a green manure. Plants up to pre-bloom stage should only be used otherwise while handling such materials, dispersal may take place. It has also nematicidal properties for the control of root-knot nematodes. Fruit and receptacles contain water soluble plant growth inhibitors which are detrimental to certain weeds in aquatic system [37]. It has medicinal properties too. Use of *Parthenium* for such purpose will reduce the further build up of soil seed bank.

Prevention

Preventing the spread of *Parthenium* is the most cost-effective management strategy. It is one of the most important means to check the spread of *Parthenium* to another area. Strict quarantine laws not to transport infested seed and nursery stock from infested to non-infested area should be enacted. Nobody should be allowed to have *Parthenium* plants in the vicinity of his home or crop fields/ orchards. There is a high risk of spreading *Parthenium* by the movement of vehicles, livestock and crop produce. Also, cattle feed and crop seeds purchased from infested areas should be checked thoroughly for contamination by *Parthenium* plants.

Physical and cultural

Though this method is expensive and time consuming, it can provide some relief for future. In croplands hand hoeing and weeding before the plant blooms should be done. All uprooted plants should be collected at one place and burnt. This should be repeated 3-4 times in a season to check for all the flushes. Cutting and slashing of the plants should be done before flowering but the plants can regrow from crown buds [30]. In fallow lands ploughing should be done before the weed starts flowering. In areas where *Parthenium* infestation is very recent, hand pulling along with roots at pre flowering stage should be followed. This should be done when the soil is moist. The, rubber gloves or any other protective covering should be used to avoid possible danger to develop allergy [30].

Manipulation of sowing time and seed rate of crops can reduce the infestation of parthenium. Early sowing before the rains start can give advantage of first rains to crop for an early establishment. When the sowing is delayed the emerged weed plants can be killed while preparing the land for sowing. However, buried seeds may come to upper soil surface but this can help in reducing the soil seed bank. Use of higher crop seed rate will help in shading effect or reduced space for the weed. However, quick germinating and fast growing crops such as cowpea, faba bean, peas and common bean and either alone or as an inter-crop can suppress and reduce the competition.

Herbicidal

A large number of herbicides have been tried to control parthenium. Of these, use of glyphosate, atrazine, and metribuzin has been promising. Timing of herbicidal application is critical. The plants should be treated before flowering and seed setting and when other plants especially grass are actively growing to recolonise the infested area. In open non crop areas, and along railway tracks and roadsides, spraying of a solution of common salt (15-20%) in active growth stage of the weed can be effective. Application of glyphosate (0.1%), paraquat (0.1-0.2%) and diquat (0.1%) give good control. But paraquat is effective only up to 3-5 leaf stage where as diquat can control weeds up to 12-15 leaf stage. Application of glyphosate at rosette stage proves very effective in controlling the weed [30]. For grown up plants 2,4-D Na 2.5kg/ha + MSMA 5kg/ha with 5kg urea/ha in 1000 liter water should be used. Other herbicides are glufosinate-ammonium (0.1%), chlorimuron (0.02-0.04%) metsulfuron (3.5-4.5kg/ha) and 2, 4-D ester (0.2 -0.5%) and bromacil (0.2%) for flowered plants [30,67].

In pasture and grasslands metribuzin (0.3%) can be sprayed when the weed is in active growing stage. For crops number of herbicides are available which can provide control of *Parthenium* up to 2-5 months. In maize, sorghum, sugarcane and pearl millet infested fields preemergence application of atrazine (1.0-1.5kg/ha) can be done. Application of alachlor (1.5-2.0kg/ha) or pendimethalin (1.2-1.5kg/ha) as preemergence in all most all the pulses, cereals, oilseeds and vegetable crops including potato is effective while metribuzin (0.5-0.75kg/ha) in wheat, maize, barley and sugar cane can give effective control. In cotton norflurazon, flumeturon and in groundnut flumioxazin preemergence or chlorimuron post-emergence at rosette stage of weed can be applied for effective control. In orchards, 2,4-D, glufosinate, glyphosate, norflurazon and pendimethalin can be applied.

Biological

In any country vast non-crop areas infested with parthenium, the herbicidal application may not only be difficult and expensive but also may result in long term environmental pollution and possible serious problems which may be encountered in future. The plant species which adapt to a wide range of environmental conditions possess rapid growth, deep root system, efficient in resource utilization and are more allelopathic can also be utilized for repression of parthenium. Therefore, under such situations harmless plants which help in inhibiting the growth and spread as well as utilizing insect bioagents to check growth of *Parthenium* is very important. Though these methods are slow but can prove more efficient.

Certain plant species have been found to suppress the germination and growth of *Parthenium* due to their allelopathic impact and these plants have gradually replaced the weed

in India. *Cassia uniflora*, *C.tora*, *C. auriculata*, *C. occidentalis* and *Stylosanthes scabra* seeds can be broadcasted in infested roadsides and non-crop areas which will gradually replace the weed [42,68]. Most of these replacement plants are non palatable to livestock thus can flourish well to replace parthenium. In India, marigold (*Tagetes erecta*; *T. minuta*) directed seeded or transplanted in infested areas during rainy season had great potential in replacing the weed [69]. Other plant species which hold promise are *Tephrosea purpurea*, *Sida latifolia* and *Croton sparciflorus*. Certain legumes and useful pasture grasses like *Bothriochloa insclupta*, *Clitoria ternatea*, *Cenchrus ciliaris*, *Chloris ventricosa*, *Eragrostis curvula* [8,45,70] can be used in pasture and grazinglands.

Several biocontrol agents (insects and pathogens) have been released from time to time to manage the weed biologically. The leaf feeding beetle *Zygogramma bicolorata* is widely used in several countries to manage parthenium. *Z. bicolorata* is a leaf feeding beetle which has been successfully been introduced in Australia, South Africa and India, and in Ethiopia too this insect bioagent has been found successful and will be released soon. Experiment with the stem boring weevil *Listronotus setosipennis* is in progress. However, when releasing two different bioagents their compatibility and competitiveness should be considered, otherwise must be released in difference agro ecologies.

Awareness

Unlike other weeds, *Parthenium* can invade any area in villages, towns and cities in the vicinity of residential and other buildings. Mass awareness programmes should be organized involving all citizens, students, NGO's and governmental and private organization to make them aware of the dangers of this noxious invasive weed. The students can serve as an excellent source of mass dissemination of knowledge about the hazards of *Parthenium* and its uprooting among the people in areas from which they come from. If we want to save our future generations' *Parthenium* awareness week should be organized thorough out the country once a year and it should be given the same status as for Anti- HIV/AIDS campaign.

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