ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

OFFICE OF GRADUATE STUDIES

Distribution Status and Impact of *Parthenium hysterophorus* L., on Teff, Maize and Haricot Bean Growth: The Case of Awash Melkasa area, East Shoa Zone, Oromia, Ethiopia

A Thesis

Submitted to the Department of Biology

School of Applied Natural Science

In Partial Fulfillment of the Requirements for the Degree of Master in Biology

By

Million Damte Deneke

Adama, Ethiopia

September, 2017

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September, 2017

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List of Abbreviations and Acronyms

APFISN	Asian-Pacific Forest Invasive Species Network
AWC	Australian Weeds Committee
Cm	Centimeter
EARO	Ethiopian Agricultural Research Organization
EC	Ethiopian Calendar
FYM	Farm Yard Manure
GIS	Geographical information system
IAS	Invasive Alien Species
Km	Kilometer
m^2	Square meter
MC	Milli-Compost
NPK	Nitrogen, Phosphorus, Potassium
OPC	Ordinary *Parthenium* Compost
PAG	*Parthenium* Action Group
SPSS	Statistical Package for Social Science
SQL	Sesquiterpene Lactone

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Abstract

Parthenium hysterophorus is an alien invasive weed of pastures, marginal lands and agricultural fields, particularly in developing world. Various problems were posed by the weed to human health, agriculture, livestock production and biodiversity. The study was conducted from September 2016 to July 2017, to evaluate the distribution status and impacts of *Parthenium hysterophorus* on teff, maize and haricot bean growth in Awash Melkasa area. Seven kebeles around the study area were selected to study the distribution status and impacts of *Parthenium* on crops mentioned above. To investigate the distribution of the weed, a total of 9 quadrats (each1m^2) from each kebeles were selected by using stratified random sampling. The field study showed significant distribution of the weed (with Simpson index of diversity 0.49). The allelopatic effect of *P. hysterophorus* on teff (*Eragrostis tef*), maize (*Zea mays*) and haricot bean (*Phaseolus vulgaris*) were evaluated on *Parthenium* compost. The allelopatic study conducted on *Parthenium* compost showed that maize has better height, 150 cm, whereas the height of teff, 65.33 cm and the haricot bean, 80 cm were affected during the entire cropping season. Even, five of the haricot beans from the experimental group were died. The result of this study also revealed that the maximum tolerance index was observed in maize,(130) followed by teff (85.2) and the minimum was observed in haricot bean (66.6). The highest phytotoxic effect was observed on haricot bean (33.33%) and then on teff (14.79%) and the minimum was observed on maize (-30.43%). To measure soil pH and moisture in both *Partheium* bounded and non-*Partuenium* bounded soil were randomly sampled, weighed in the field and taken to laboratory. The result of the study showed that, the amount of available soil moisture is slightly more in *Parthenium b*ound soil than in non-*Parthenium* bound soil. The mean value of soil pH of *Parthenium* bound soil is also higher than non-*Parthenium* bound soil. So it could be concluded that, the infestation level of the weed is higher in the study area, which could have significant effect on biodiversity, major agronomic characteristics like shoot growth, and physical and chemical features of soil, such as soil moisture content and pH. So that, integrated efforts should be practiced to control the aggressive invasion and the danger of the weed at local, regional and national level till the complete seed bank is exhausted.

Key words: Allelopatic, Agronomic, Awash Melkasa, Biodiversity, Diversity index,

Parthenium hysterophorus

1. INTRODUCTION

1.1 Background of the Study

Parthenium (*Parthenium hysterophorus* L.) also known as congress grass, carrot weed, ragweed *parthenium*, white top, is an invasive poisonous herbaceous annual weed in the member of the plant family *Asteraceae*. It is native to Central America and now it is widely distributed in India, China, Australia and Africa (Navie *et al*., 1996). Its introduction to Ethiopia was probably via food grain aid from North America (Kassahun *et al*., 1999) and/or army vehicles during the 1976 - 1977 Ethio-Somalia war (Tamado and Milberg, 2000). Currently, the weed has become the most dominant weed and is ranked as the worst and more frequent species of weed in arable and grazing land, abandoned fields, open woodlands, flood plains and along river banks, roadsides and residential areas of the country (Rezene *et al.*, 2005; Asresie *et al*., 2008; Ashebir *et al*., 2012).

Parthenium was first reported from Ethiopia in 1988 at Dire-Dawa and Hararge, eastern Ethiopia and subsequently found near Desse, north- eastern Ethiopia as well. Both are major food- aid distribution centers and there is strong assertion that *Parthenium* weed seeds were imported from sub- tropical North America as a contaminant of grain food-aid during the 1980s famine and distributed with the grain (Tamado *et al., 2002a*). Moreover, population pressure, over- sticking, over-grazing and deforestation have facilitated the disturbance of Ethiopian ecosystem and enhanced the effect of weed invasion that threatened the biodiversity (EARO, 2003).

P. hysterophorus is one of the Invasive Alien Species (IAS) that was introduced from outside its natural range of distribution by either intentional or unintentional human activity, has established self-producing populations in wild and has caused oblivious changes in the ecosystems. Invasion is considered as the second most important threat to biodiversity after habitat destruction (Akter and Zuberi, 2009). *P. hysterophorus* family *Asteraceae,* is an invasive alien weed of global concern and has become a major weed in Australia, Africa, and many other parts of the world (Adkins and Navie, 2006). The invader weed is either accidentally introduced or deliberately introduced. After introduction the weeds may expand their population very rapidly and spoils the biodiversity (Akter and Zuberi, 2009; Karim, 2009).

The major ecological and morphological characteristics that contribute to severe invasiveness of *Parthenium* weed might be its adaptability to wide agro climatic and ediaphic conditions (Navie *et al*., 1996). The lightness of the seed, prolific seed production, and adaptability to a wide range of habitats, drought tolerance, its ability to release toxic chemicals against other plants (allelopathy), and its rapid growth rate allow it to colonize new areas quickly and extensively. It can cause severe crop yield losses. In India, a yield reduction of 40% in agricultural crops (Khosla and Sobti, 1981) and 90% reduction in forage production were reported. In eastern Africa, *Parthenium* reduces the yield of many major crops such as sorghum and corn, competes with preferred pasture species and when consumed by domestic animals, taints their milk and meat, reducing their value. It also causes human health problems such as severe contact dermatitis and respiratory problems (Tamado, 2001),

In Ethiopia, *P. hysterophorus*, affects range lands, forest lands, crop lands, gardens, orchards, and has a significant role in yield reduction (Taye *et al*., 2004). Other than direct competition with crops, *Parthenium* weed poses allelopathic effect on different crops and other plants (Mersie and Singh, 1988; Evans, 1997; Adkins, 2002, Wakjira *et al*., 2005; Adkins and Naïve, 2006).

As Ayana *et al*., (2011) reported, Awash National park, one of the prominent national parks in Ethiopia and where a number of wild animals and various woods and herbaceous species inhabit has been at risk due to the aggressive spread of the *Parthenium* weed. Herbaceous vegetation is the dominant component of most wild life reserve areas. It was reported as *Parthenium* weed has the potential to decline adversely the herbaceous components of the vegetation up to 90% by its aggressive competition and allopathic effect (APFISN, 2007). Also valuable species in the infested area which were essential for grazing animals have already disappeared due to the continued increase of *Parthenium* weed and livestock selection pressure. Since the selected site was less prone to the influence of livestock or other grazing animals, the declined in stand crop biomass of herbaceous plants in infested quadrats was most probably due to *Parthenium* weed. This above all can shrink the biodiversity of the park and hinders the attractiveness of the national economy. Ethiopia is currently one of the affected countries in the region.

Therefore, *P. hysterophorus* is considered to be the most important weed both in crop lands and grazing areas by 90% of farmers in the low lands of Ethiopia(Tamado and Millberg, 2000) with

sorghum yields being reduced by 97% in experimental fields with high densities of *Parthenium* weed (Tamado *et al.*, 2002). Looking at the multitude of harms caused by *P. hysterophorus*, its management is necessary to prevent future problems. Since *P. hysterophorus*, grows luxuriantly in many parts of the world, it is important to explore its beneficial uses if any. Several methods have been developed for the control of *Parthenium*, each has its own limitations. For instance, removing *Parthenium* by slashing or mowing as soon as or before it flowers, though it prevents seed production, results in regeneration of new shoots leading to a repeated operation (Ganavel, 2013).

Manual and mechanical uprooting also proved to be of limited value owing to enormous amount of labor and time required (Berhanu,1992), and vulnerability of workers engaged in the operation to the various kinds of allergies caused by the weed(Kololgi *et al.*, 1997). Chemical control, though effective, is temporary and needs repeated application, besides it has problems of residues, selectivity, availability and cost of application (Singh, 1997). Hence, the use of bio-control agents including insects, pathogens and strong interfering smoother crops are recommended for the long-term management of *Parthenium* (Adkins, 2002b). Other than competition and allelopathic effect on different crops (Navie *et al*., 1996), *Parthenium* poses health hazard to humans (Kololgi *et al*., 1997) and animals (Chippendale and Panneta 1994).

The uncontrolled expansion, fast growth and rapid spread of *Parthenium* weed around east Ethiopia particularly around Awash Melkasa is an alarm for the local farmers so as to rescue the productivity of crops. Hence this study was aimed to assess the distribution status and impact of introduced species, *P. hysiterophorus,* on teff, maize and haricot bean growth in the area.

1.2. Statement of the Problem

In Ethiopian, disease, insects and weeds contribute to a loss of 40% yield reduction in field crops (Tamado, 2002). Especially, weeds are one of the biotic stressors which have contributed to reduce the level of grain yield, quality of fruits, vegetables, cereals, and incurred high level of herbicide cost. Hence, they have a strong share in the stagnation of the country's national economy (Taye *et al.*, 2004). *Parthenium* weed is one of the aggressive invasive species that can cause significant and sometimes irreversible environmental and socio- economic impact at the genetic, species and ecosystem levels (Hens & Boon, 2003).

Parthenium exerts strong allelopathic effect and reduces the growth and reproduction of associated crops. It does these by releasing phytotoxins from its decomposing biomass and root exudates in soil. Bioassay, pot culture and field studies have revealed that all plant parts (shoot, root, inflorescence and seed) are toxic to plants (Mulatu *et al*., 2009). Currently, the weed has been distributed to different regional states of Ethiopia, eastern to southern including in East Showa zone Awash Melkasa area. However, the local people and the concerned bodies have not give attention to the weed. *Parthenium* brings a negative impact on crop productivity, farmland, arable land, rangeland, biodiversity, animals and human health. The occurrence of *P. hysterophorus* is very frequent in rural and urban areas of Eastern Ethiopia, Oromia Region Awash Melkasa area.

1.3 Significance of the Study

Currently there are different types of alien invasive species of plants in Ethiopia as *Prosopis juliflora, P. hysterophorus* and *Lantana camara*. These invasive species have allelopathic effects on native plants, that is, they out compete native species and dominate the ecosystem (environment). Even if there are different invasive species in the study area, this study is concerned with the distribution and impacts of *P. hysterophorus*. So the information obtained from the study is used to devise the strategies for intervention towards the control of P. *hysterophorus* weed where stakeholders: farmers, agriculture extension workers, Woreda and Zonal agricultural office, and agricultural research centers will be beneficiary. It will, also be input for the policy makers so as to control the weed.

1.4. Research Questions

1. What factors make *Parthenium haysterophorus* (known as ‘‘ferremsisa’’ locally) infest Awash Melkasa and nearby areas?
2. What is the distribution status of the invasive alien species, *P. hysterophrus*, around Awash Melkasa area?
3. What seasons are conducive for better growth and dispersion of *Parthenium*?
4. Does *Parthenium* affect the physical and chemical features of the soil?
5. Which crop plant is highly affected by the allelopatic chemicals of this noxious invasive weed?

1. 5. Research Hypothesis

The following research hypotheses were set:

1. *P. hysterophorus* would affect biodiversity or ecosystem by affecting mainly plants, by competing for resources with native plant species and by producing chemical substances that affect the growth of plants.

2. *P. hysterophorus* could negatively affect crop plant growth and reducing native plant biodiversity.

3. P. *hsterophorus* could be sources of essential nutrients for crop plants, if it is composted scientifically.

1.6. Scope of the Study

The study must be limited both in scope and depth to a manageable size based on the researcher's time availability, budget and other factors. On the basis of these situations the scope of the study is delimited to Awash Melkasa area, Adama district, East Shewa zone, Oromia, Ethiopia, which consists of six rural kebeles (Adulala Boku, Adulala Hatie, Awash Melkasa, Rogge Balewold, Waga Malka Aba and Waqmey Tiyo) and one urban kebele (Awash Melkasa town). It is also delimited on the distribution and impact of *Parthenium hysterophorus* on teff , maize and haricot bean growth in the study area.

1.7. Objectives of the Study

1.7.1 General objective

- The General objective of this study is to investigate the distribution status of *Parthenium hyterophorus* and assess the impact of the weed on teff, maize and haricot bean growth in Awash Melkasa area.

1.7.2. Specific objectives

The specific objectives of the study are:

- To investigate the status of the *Parthenium hysterophorus* distribution in Awash Melkasa area.
- To investigate the impact of *Parthenium hysterophorus*, on selected crops and native plant diversity in Awash Melkasa area.

- To investigate its allelopatic effect and identify how and to what extent *Parthenium* affects the qualitative height growth of crop plants.
- To investigate the level of phytotxicity of the weed on selected crops and their tolerance index due to *Parthenium* compost treatment.
- To determine the effect of *Parthenium* on soil physical and chemical characteristics, such as soil moisture content and soil pH.

2. LITERATURE REVIEW

2.1. Biology of *Parthenium* Weed

Parthenium hysterophorus is an annual herb, erect, up to 2 m in height; the stem is branched and covered with trichomes. Leaves are pale green, lobed, hairy, initially forming a basal rosette of strongly dissected leaves that are up to 30 cm in length, close to the soil, alternate, sessile, irregularly dissected and bipinnate, having small hairs on both the sides, resembling the leaves of carrot. The number of leaves per plant ranges from 6 to 55. Flower heads are creamy white, about 4 mm across, arising from the leaf forks. Flowering occurs about a month after germination.

A large single plant produces up to 100,000 seeds in its lifecycle which are small in size, (1-2 mm diameter) and light in weight to travel long distances through wind, water and other means. More than 340 million seeds per ha can be present in the surface soil. Seeds do not have a dormancy period and are capable of germinating anytime when moisture is available. The highest germination rates are at temperatures ranging from 12 °C to 27 °C. The root system has one main branched taproot and many finer roots (Abebe and Chemeda, 2016)

The scientific classification of *Parthenoium hysterophrous* is:-

- Kingdom – Plantae
- Division – Angiospermae
- Class – Audicots
- Order – Asteraleae
- Family – Asteraceae
- Genus – *Parthenium*
- Species-*hysterophorus*

The genus name *Parthenium* is derived from the Latin word " parthenice" a reference to the plant now known as *Tanacetum parthenium*(L.) Bernh or"feverfew;" and specific name *hysterophorus* was derived from the Greek *hystera* (womb) and *phoros* (bearing), referring to the prolific seeding habit of the plant (Parsons and Cuthbertson ,1992)

Parthenium weed (*P. hysterophorus*) popularly known as Congress grass is an erect, herbaceous annual plant, which can grow at any season and almost anywhere. It belongs to the family

Asteraceae (Compositae), an extremely diverse family with a cosmopolitan distribution. *Parthenium hysterophorus*(Common name: Bitter weed, false rage weed, fever few, *Parthenium* weed, Rage weed, white top etc:) is profusely branched herb. *Parthenium* weed height varies from 50- 150 cm. Its stem is highly branched; leaf simple, disc floret: numerous stamen -4, anther – erected: ovary sterile: ray floret: found just opposite to inner phullaries, only 5 ray floret per flower head, corolla obsolete, stigma parted, style short, ovary oval stamen absent, dorsi-ventrally flattened. Fruit cypsela, each flower head bears 5 cypsela, and flat or triangular in shape with thin, white spoon shaped appendages (Maharjan, 2007).

2.1.1. Reproductive capacity of *Parthenium* under different climatic conditions.

P. hysterophorus is able to grow on a wide range of soil types ranging from sandy to heavy clays. *Parthenium* weed occurs in areas with summer rain fall greater than 500 mm per annum and a drought- tolerant plant. *Parthenium* weed seeds can germinate in wide range of temperatures, including as low as 10^0C or as high as 36^0C. The viability of *Parthenium* weed seed was also found to be > 90% in the temperature range 12-150^{o}C. The viability of *Parthenium* weed seed was >15% after 26 months of burial in the soil and that the "half- life" of seeds in the soil was 3-4 years (Tamado *et al.*, 2002 a). Warm conditions promote the reproductive ability of *Parthenium* weed, such as increasing seed production and seed fill percentages, promoting seed production and producing seed with the capacity to live longer in the soil seed bank (Nguyen *et al.*, 2011).

According to Brahman (2003) a single plant of *Parthenium* weed can produce 10,000 to 15,000 viable seeds that occupy roadsides, tank bunds, fence lines, wastelands, agricultural fields, forestlands, and rangelands. *Parthenium* Action Group (2000) stated that *P. hysterophorus* could produce large quantities of seed, up to 100,000 per plant and more than 340 million seeds per hectare in the surface soil, compared to 120,000 of native grass seeds. In cultivated lands where only one crop is taken in a year, *P. hysterophorus* grows in the fallow period with one or two rains but its growth and reproductive ability will be affected depending upon soil fertility and rainfall. Frew *et al*., (1996) stated that *P .hysterophrus* could grow under varied soil p^H. The plant has a remarkable plasticity and adaptability to environmental stresses

2.2. Distribution of *Parthenium hysterophorus* in the World

P. hysterophorus is naturally a weed of sub-tropical areas of North and South America (Mexico, USA and West Indies), but later it found its way accidentally to tropical and subtropical parts of Africa, Asia and Australia during the last five decades (Aneja *et al*., 1991)

According to Navie *et al*. (1996), *P. hysterophorus* is widely distributed in South and East Africa (Ethiopia , Kenya), and South East Asia (India, China Vietnam, and the pacific Islands), Australia (Queensland, Central Highlands and North Clermont, New South Wales) and in many other parts of the world cutting across country boundary and climate barrier. That is why *P. hysterophorus* bears a number of common names like *P. hysterophorus* in Australia, congress grass, carrot weed bitter weed, broom bush, and star weed in India, false ragweed, ragweed in USA, white top, Escobar amarga, and feverfew in the Caribbean.

Invasion of *P. hysterophorus* weed is attributed to many factors like wider adaptation across climates, photo-insensitivity, drought tolerance and absence of seed dormancy. Within a short period of time, *P. hysterophorus* has become a major weed of regional, national or international concern (Haseler, 1976). This might be because of its prolific seed production ability and small and light weight seeds that are capable to travel long distances through wind, water, birds and other animals and transported goods serve as vectors for the dispersal of seeds.

2.2.1. Distribution of *Parthenium hysterophrus* in Africa

Recent surveys detected severe negative impacts of *P. hysterophorus* where subsistence and pastoral agriculture are of crucial importance like countries in Ethiopia, Swaziland and South Africa, the Ethiopian farmers refer to *Parenthenium. hysterophorus* as *'klidnole'* (living alone) or '*feremsis*' meaning' signoff'(and leave your farm), reflecting its economic importance. Even many farmers have been forced to abandon grazing and cultivated land invaded by *P. hysterophorus.* The world famous, Masai Mara ecosystem in Kenya, which hosts the largest wildlife migration known to human, is under attack from this noxious weed from Central America, became a serious concern. If left unchecked it could threaten the continued migration of millions of animals across the plains every year (IUCN, 2010).

Parthenium was first detected in Uganda in 2008 and a follow-up survey carried out in Eastern and Western Uganda in July/August 2010 for the distribution of the weed in Uganda detected this weed in several districts indicating recent spread to new locations. In Tanzania, surveys conducted in 2010 along selected road networks found it in Kilimanjaro International air port area, near Arusha airport, and around Arusha town. First recorded in South Africa in 1880, in KwaZulu-Natal province becoming common and invasive in Mozambique, but not in Zimbabwe, but since1982 found spreading relatively slowly around Harare in Zimbabwe (Mcconnachie *et al.,* 2010).

2.2.2. Distribution of *Parthenium hysterophorus* in Ethiopia

P. hysterophorus was first reported from Ethiopia at Dire-Dawa, Harerge, and eastern Ethiopia in 1988 (Tamado and Milberg, 2000). According to the recently published volume of Flora of Ethiopia and Eritrea, *P. hysterophorus* is distributed in eastern Ethiopia along the Dire Dawa-Addis Ababa railway, Central Showa and Wollo, northern Ethiopia, Sidamo along the main road from Moyale to Asella (Mesfin *et al*., 2004). Most are major food-aid distribution centers, and there is a strong justification that *P. hysterophorus* seeds were imported from subtropical North America as a contaminant of grain food aid during the 1980s famine, and distributed with the grain. *P. hysterophorus* has been causing serious damage in Ethiopia since its discovery in 1980's as an exotic invasive species. Frew *et al*. (1996) reported its status, distribution and biology.

P. hysterophorus seeds have the possibility of trans boundary transfer and the capacity to travel long distances through wind, water and other means (Taye, 2002). It is therefore, possible that *P. hysterophorus* could have easily been introduced to Ethiopia from the neighboring countries. Taye *et al*. (2004), indicated that the presence of *Puccinia abrupta* on *P. hysterophorus* in Ethiopia might explain indirectly the introduction of *P. hysterophorus* from neighboring countries, Kenya and /or Somalia since the presence of the species has been reported earlier from Kenya. However, there is no concrete evidence with regard to the question of how and when *P. hysterophorus* got introduced into the country.

2.2.3. Colonization and spread of *Parthenium hysterophorus*

Parthenium weed colonizes a range of vegetation and soil types but the most common are the alkaline clay loam to clay soils on downs; floodplains and soft wood, brig low and ridge scrub

country. *Parthenium* weed is extremely effective at colonizing and is a highly competitive plant. It will colonize weak or over-grazed pastures with low ground cover; cultivated lands; disturbed and areas such as stock- yards and watering points. *Parthenium* seed is spread easily by water, farm and industrial machinery, feral animals, humans, vehicles, stock fodder and movement of stock, grain and seed. After introduction the weed may expand their population very rapidly and damage the biodiversity. It has been introduced to many countries in Africa, Asia and the Pacific and has become a major weed (Akter and Zuberi, (2009).

2.3. Allelopathic Properties of *Parthenium hysterophorus*

Parthenium contains chemicals, like Parthenin, hysterin, hymenin, and ambrosin, and due to the presence of these chemicals, the weed exerts strong allelopathic effects on different crops, in addition to its direct competition for nutrients, water and sunlight. *Parthenin* has been reported as a germination and radical growth inhibitor in a variety of dicot and monocot plants (Gunaseelan, 1998). *Parthenium* has a strong ability to affect crop growth through allelopathy. There is a strong evidence (Knox *et al*., 2011) that aqueous extracts of leaf, inflorescence, stem, and root of *Parthenium* weed reduce germination, root/shoot length, root/ shoot dry weights, total seedling dry weight, plant height, leaf area, spikelet and pod number, seed weight, grain yield, water content, chlorophyll contents, enzyme activities, and reducing and non-reducing sugars of cereals, pulses, forages, oilseeds, and vegetables. Also according to Khosla and Sobti (1981) the weed affects nodulation in legumes due to inhibition of activity of nitrogen fixing and nitrifying bacteria, namely, *Rhizobium,Actinomycetes, Azotobacter*, and *Azospirillum.* Also Kanchan and Jayachandra (1981) and Dayama (1986), reported that the growth and nodulation of legumes were inhibited by *parthenium* weed because of the inhibitory effect of allelochemicals on nitrogen fixing and nitrifying bacteria. These chemicals have been observed to exhibit an inhibitory effect both on the germination and growth of a wide variety of crops including pasture grasses, cereals, vegetables, other weeds and even tree species (Evans,1997a; Navie *et al*.,1996;). *Parthenium* produces enormous numbers of pollens (on an average 624 million/plant), which are carried away at least to short distance in clusters of 600–800 grains, and settles on the vegetative and floral parts, including stigmatic surface, and inhibiting fruit setting in crops like tomato, beans, capsicum, and maize. Additionally, *Parthenium* weed pollen was found to reduce the chlorophyll content of leaves to which it comes in contact with and can interfere with the pollen

germination and fruit set of the nearby species (Kanchan and Jayachandra, 1980b). Aneja (1999) and Tamado *et.al*, (2002), reported that, in India, *P. hysterophorus* causes a yield decline of up to 40% in agricultural crops. Sorghum (*Sorghum bicolora* L. Moench) grain yield losses between 40 and 97% have been reported in Ethiopia if *Parthenium is* left uncontrolled throughout the season. Channappagoudar *et al*. (1990), also reported that the presence of *Parthenium* weed in irrigated sorghum in India reduced grain yields from 6.47 to 4.25 tons/ha (34.3%) and decreased grain weight by 30%. However, its overall impact on the production system is multifaceted, both direct and indirect, thus making it difficult to quantify losses (Evans, 1997). In addition to its allelopathic effects on crop plants *Parthenium* affects the germination and growth of non-crop plants, it can also cause greater impact in reducing the productivity of plants and animals.

The allelopathic properties are largely classified as secondary plant metabolites of *Parthenium* weed and its ability to inhibit the growth and development of other species is well documented (Belz *et al*., 2007). The most common effects of allelopatic chemicals may occur though leeching, volatilization, root exudation and decay of the fallen parts either through biotic or abiotic means. Positive and negative allelopathic effects have been reported of *P.hysterophorus* on many plant species are sesquiterpene lactone and phenolics. *Parthenium* weed is the major sesquiterpene lactone whereas caffeic, vanillic, ferulic, chlorogenic and anisic acids are the major phenolics (Batish *et al*., 2002).

2.4. Chemical Composition of *Parthenium hysterophorus*

Isolation and structural elucidation of the active principles of *P. hysterophorus* is required to determine their chemical properties. Chemical composition of *P. hysterophorus* has indicated that all its parts including trichomes and pollen contain toxins called sesquiterpene lactones (SQL). Maishi *et al*. (1998), reported that *P. hysterophorus* contains a bitter glycoside parthenin, a major sesquiterpene lactone. Other phyto-toxic compounds or allelo-chemicals are hysterin, ambrosin, flavonoids such as quercelagetin 3,7-dimethylether, 6- hydroxyl kaempterol 3-0 arabino glucoside, fumaric acid. P-hydroxyl benzoic and vanillic acid, chlorogenic acid, ferulic acid, sitosterol and some unidentified alcohols, parthenin, hymenin and ambrosin are found to be the culprits behind the menacing role of this weed in provoking health hazards (Lata *et al.*, 2008). Das *et al.* (2007), examined the flowers of *P. hysterophorus* and isolated four acetylated

pseudo guaianolides along with several unknown constituents. A novel sesquiterpenoid, has been isolated along with several known compounds from the whole plant (Venkataiah *et al*., 2003).

2.5. Impacts of *Parthenium* Weed

2.5.1. Health hazards to humans and live stocks

Parthenium weed is known to cause many health hazards which have now reached epidemic proportions. Agriculturists are concerned about *P. hysterophorus* affecting food and fodder crops, since the pollen and dust of this weed elicit allergic contact dermatitis in humans (Gunaseelan 1987, Morin *et al*., 2009). Dermatitis is a T cell- mediated immune injury and the disease manifests as itchy erythematous papules and papulo vesicular lesions on exposed areas of the body (Akhtar *et al*., 2010). These effects have been related to phytotoxicity of the sesquiterpene lactone, parthenin (Narasimban *et al*., 1984). Persons exposed to this plant for prolonged period manifest the symptoms of skin inflammation, eczema, asthma, allergic rhinitis, hay fever, black spots, burning and blisters around eyes. *Parthenium hysterophorus* also causes diarrhea, severe papularerythematous eruptions, breathlessness and choking (Maishi *et al*., 1998). Exposure to *P.hysterophorus* pollen grainss cause allergic bronchitis (Tower and Subba Rao, 1992). Ramos *et al*. (2001), assessed the mutagenic potential of a crude extract of *P. hysterophorus* in the Salmonella microsome assay and the mouse bone marrow micronucleus test. However, it did not show genotoxic potential. Sharma *et al*. (2005), observed that, the clinical pattern of *Parthenium* dermatitis progresses from airborne contact dermatitis to mixed pattern or chronic actinic dermatitis pattern. Eczema herpeticum is reported to complicate *Parthenium* dermatitis.

According to, Sriramarao *et al*. (1993), worked on the use of murine polyclonal anti-idiotypic antibodies as surrogate allergens in the diagnosis of *P. hysterophorus* hypersensensitivity *Parthenium*-sensitive patient with rhinitis who had positive result on skin prick test to *P. hysterophorus* pollen extract responded with a positive skin reaction. Exposure to *P. hysterophorus* also causes systemic toxicity in livestock (Gunaseelan, 1987). Alopecia, loss of skin pigmentation, dermatitis and diarrhea has been reported in animals feeding on *Parthenium* weed. Degenerative changes in both the liver of cattle and sheep (Rakumar *et al*.,1988) the milk and meat quality of cattle, buffalo and sheep deteriorate on consumption of this weed (Lakshmi

and Srinivas, 2007). Significant reduction in rat WBC count after oral treatment of *Parthenium* extract signifies its immune system weakened (Yadav *et al*., 2010).

2.5.2. Reducing agricultural and pasture productivity

Parthenium weed is serious problem on pastures and crops. Aqueous extracts of shoot, leaf flower and root of *Parthenium* weed exhibited allelopathic effect on soybean and haricot bean seed germination rate, and shoot and root growth and dry matter production of seedling (Netsere and Mendesil, 2011). Maharjan *et al*., (2007) found that leaf aqueous extracts of *P.hysterophorus* exhibited significant inhibitory effects on seed germination and seedling growth of three cereal crops i.e *Oryza sativa, Triticum aestivum* and *Zea mays*; three crucifer vegetables, i.e *Raphanus sativus, ,Brassica campestris*, *Brassica oleraceal*; and two Asteraceae species i.e *Ageratina adenophora* and *Arthemissia dubia*. Khan *et al*. (2012), also reported that the seed germination as well as the seedling growth of wheat was the most inhabited one by the *parthenium* root, stem and leaf extracts. Similarly, Devi and Dutta (2012), found that the aqueous extract of *Parthenium* inhibit seed germination and seedling vigor of *Zea mays*. Sorghum grain yields losses between 40 and 97% were reported in Ethiopia if *Parthenium* is left uncontrolled throughout the season (Tamado *et al*., 2002b).

Singh *et al*. (2003), explored the allelopathic properties of unburnt and burnt residues of *P. hysterophorus* on the growth of winter crops, radish and chickpeas. The extract prepared from both unburnt and burnt was toxic to the seedling length and dry weight of the test crops. Burnt extract was more toxic due to its highly alkaline nature. Growth studies conducted in soil amended with unburnt and burnt extracts revealed phytoxic effects towards test crops, unburnt been more active than burnt unlike crude extracts. These effects were attributed to the presence of phenolics (Singh *et al.,* 2003). *Parthenium* leaching as root exudates plays a pivotal role in allelopathic interference with surrounding plants (Belz *et al*., 2007). Burning of *parthenium* weed in fields reduced germination, biomass growth, plumule and radical length of *Phaseolus mungo* (Kumar and Kumar, 2010). Poor fruiting of leguminous crops and reduction in chlorophyll content of crop plants were observed in *P. hysterophorus* infested fields (Lakshmi and Srinivas, 2007). *P. hysterophorus* played role as alternate host for crop pests functioning as an inoculums source. This weed has been reported to serve as a reservoir plant of scarab beetle, a

pest of sunflower. *Parthenium* weed invasion causes changes in above ground vegetation and below ground soil nutrient contents, disturbing the entire grassland ecosystem.

2.5.3. Biodiversity loss due to *Parthenium hysterophorus*

The invasive capacity and allelopathic properties have rendered *P. hysterophorus* with the potential to disrupt the natural ecosystems. Very sparse or sometimes no other vegetation can be seen in *Parthenium* weed dominated areas. It has been reported to be causing a total habitat change in native Australian grasslands, open woodlands, river banks, and flood plains (Lakshmi and Srinivas, 2007). These weeds rapidly invade new surroundings often replace the indigenous species and pose a serious threat to biodiversity in India. Akter and Zuberi (2009), conducted an extensive survey on invasive alien species and their impact on different land use types, road side, low land, fallow land, homestead and railway track in Bangladesh. Among others, *P. hysterophorus* exhibited the ability to invade and adapt to new habitats, thereby reducing the number of indigenous plants. The more vigorous mode of reproduction and the possession of an array of secondary metabolites give the weed the status of invasive alien species.

2.6. Control Mechanism of *Parthenium* Weed

It is necessary to control the problematic weed *P. hysterophorus* in time before spreading, because of its negative impact on natural and agro ecosystem. 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. In a report, Australian Weeds Committee (2012), effective broad scale management of *Parthenium* weeds requires an integrated approach that includes prevention and eradication programs, establishment and implementation of management zones, and the protection of key environmental, social and economic assets in areas where the weeds are already widespread.

2.6.1. Disposal and eradication of *Parthenium hysterophorus* weed

Its eradication is a major challenge to government, primarily because of its epidemic proliferation and strong reproductive potential, apart from its wide ecological range. Several physical and chemical methods used in the past to eliminate this weed have proved ineffective expensive and not eco-friendly. Further, these weeds are burnt in order to prevent various ailments induced by its toxic sesqueirpene lactones. However, burning of *P. hysterophorus*

residues is not a recommended practice as it deteriorates the soil quality by rendering it more alkaline and deficient in organic matter (Singh *et al.*, 2003). Tamado and Milberg (2004), conducted experiments to compare the effect of hand hoeing and applying herbicide (2, 4-D) on growth of this weed and its effect on yield of sorghum in small holder farming system in Ethiopia. Hoeing proved to be more efficient than the use of chemical herbicide.

2.6.2. Biological control of *Parthenium hysterophorus* weeds

Dhileepan (2003), studied the effectiveness of leaf feeding beetle *Zygogramma bocolorate*, stem-galling moth *Epiblema strenuana* and stem-boring weevil *Listronotus setosipennis* introduced against *P. hysterophorus* in Australia. The moth *Carmenta ithacae* and leaf rust *Puccinia melampodi* were released to eliminate this weed, but little success has been attained in this regard as the weed has great regenerative potential and moreover, the insect consumes only the foliage of the weed which stimulates further leafy proliferation (Dhileepan and Strathie, 2009). The flowers and seeds, which are the main source of its dissemination, remain unaffected.

Eucalyptus, a native of Australia, is a known allelopathic tree that exerts its toxicity through leachates and volatile terpenes on adjoining vegetation/ agricultural crops. The volatile terpenes present in leaves of eucalyptus emanate in the form of vapors into the surroundings. The vepors get absorbed into the soil, curbing the seed germination and reducing the chlorophyll content as well as cellular respiration. The oil vapors increase water loss leading to wilting. Eucalyptus oils may be used as natural herbicides for the bio control of *P. hysterophorus* owing to its allelochemcials. Biological control agents and competitive plants can be used in a complementary manner to achieve better management of *Parthenium* weed and the result is better than either option alone. Khan *et al*. (2010), indicated that selected pasture species purple pigeon grass, buffel grass, butter fly pea, kangaroo grass and bull and Mitchell grass are likely to be useful at displacing *Parthenium* weed in the infested region. Such displacement plants are known to work well with the already released biological control agents and together they can reduce *Parthenium* weed productivity by as much as 69%.

Recent attempts were made by Knox *et al*. (2011), to determine the allelopathic effect of *Cassia occidentalis* (Caesalpiniaceae) on the vegetative and reproductive establishment of *P. hysterophorus*. They observed a significant reduction in germination percentage, shoot cut bioassay, seedling bioassay, and chlorophyll of *P. hysterophorus* at higher concentration of shoot

leachates. Root leachates of 100% concentration of *Cassia occidentalis* obtained after a days were responsible for the maximum inhibition of nitrogen percentage and protein content of *Parthenium*, indicating that bimolecular interaction plays a significant role curbing the population dynamics this obnoxious weed with enormous seed production potential. Javaid *et al*. (2011), evaluated the allelopathic or bio herbicidal activity of *Withania somnifera*. Under laboratory condition considering 5, 10, 15 and 20% w/v concentrations of aqueous methanol and n- hexane shoot and root extracts (on a fresh weight basis) of *W. somnifera*. Their results showed that aqueous and methanol extracts markedly suppressed the germination, root and shoot growth of *Parthenium.* The shoot extracts were inhibitory than the root extracts. In a foliar spray bioassay, the aqueous and methanol shoot extracts of 10% w/v (on a dry weight basis) concentration were sprayed on l- week and 2- week old pot grown *Parthenium* seedlings. Two subsequent sprays were carried out 5 and 10 days after the first spray. The aqueous and methanol extracts significantly reduced the length and biomass of *Parthenium* shoots. In a soil amendment bioassay, the crushed shoots of *W. somnifera* were incorporated in the soil at 1-5% w/w. *Parthenium* seeds were sown one week after the residue incorporation and plants were harvested 40 days after sowing. All the soil amendment treatments significantly reduced seed germination by 43-89%. The highest dosages of 4% and 5% significantly suppressed the root and shoot biomasses of *Parthenium*. This study concludes that foliar spray of aqueous and methanol extracts and soil amendment with leaf residue of *W. somnifera*, can control the germination and growth of *Parthenium*, one of the world's worst weeds.

2.6.3. Bio composting

The *P. hysterophorus* is a rich source on N, P, K, Ca, Mg and chlororophyll content and is ideally suited for composting which is two times more than Farm yard Manure (FYM) for this reason. *Parthenium* compost aids in moisture conservation which is utilized for better root penetration and crop growth. This enhancement attributed to the higher water holding capacity of the soil due to the influence of organic waste application. The moisture in soil due to application of *Parthenium* compost was 14.5 and 16.5% at 0-15 and 15-30 cm depths as compared to 10.7 and 11.7 and 11.6% at 0-15 and 15-30 cm depths of soil due to application of NPK alone (Ambasta and Kumari, 2013). If *Parthenium* compost was prepared by scientific means then it avoids germination of non- dormant seed. It also reduces the weed growth up to 40% in the

maize due to allelopathic effect so, minimizes excessive use of pesticides. *Parthenium* compost has bacteria such as, *Azotobactor*, *Actinomycetes* that improves soil texture and fertility without affecting soil health. Finally, composting *Parthenium* before flowering is a means to minimize its allelopathic inhibition potential and one way of management by utilization. Therefore, resource poor farmers could make use of the high nutrient contents of *Parthenium* compost and could control *Psrthenium* by composting (Wakjira *et al*., 2009).

2.6.4. Cultural Management

P. hysterophorus can be controlled indirectly by using clean seed, use of more competitive varieties, and choice of an appropriate sowing rate and date, and increased amount of fertilizer. On the other hand intercropping sorghum, maize and sunflower significantly reduce *P. hysterophorus* populations. In eastern Ethiopia, reported the advantage of intercrops under sorghum cultivation systems (Tamado, 2001).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

The study was carried out in Oromia region of Ethiopia in Adama district, Awash Melkasa, one of the areas in East Shewa Administrative Zone, in the central Rift Valley of Ethiopia. It is located at 8º.24′ 0″N latitude and $39^{0}19'60''$ E longitude in DMS or 8.4 and 39.333 in decimal degrees, 17 km away from Adama town and 117 km away from the capital Addis Ababa, at an elevation of 1,550 meters above sea level. The main economic activities, in the rural areas of the selected area, are crop production which is followed by livestock rearing. There are 37 Kebeles in the Woreda and seven of which around Awash Melkasa are samples investigated in this research project (Fig. 1)

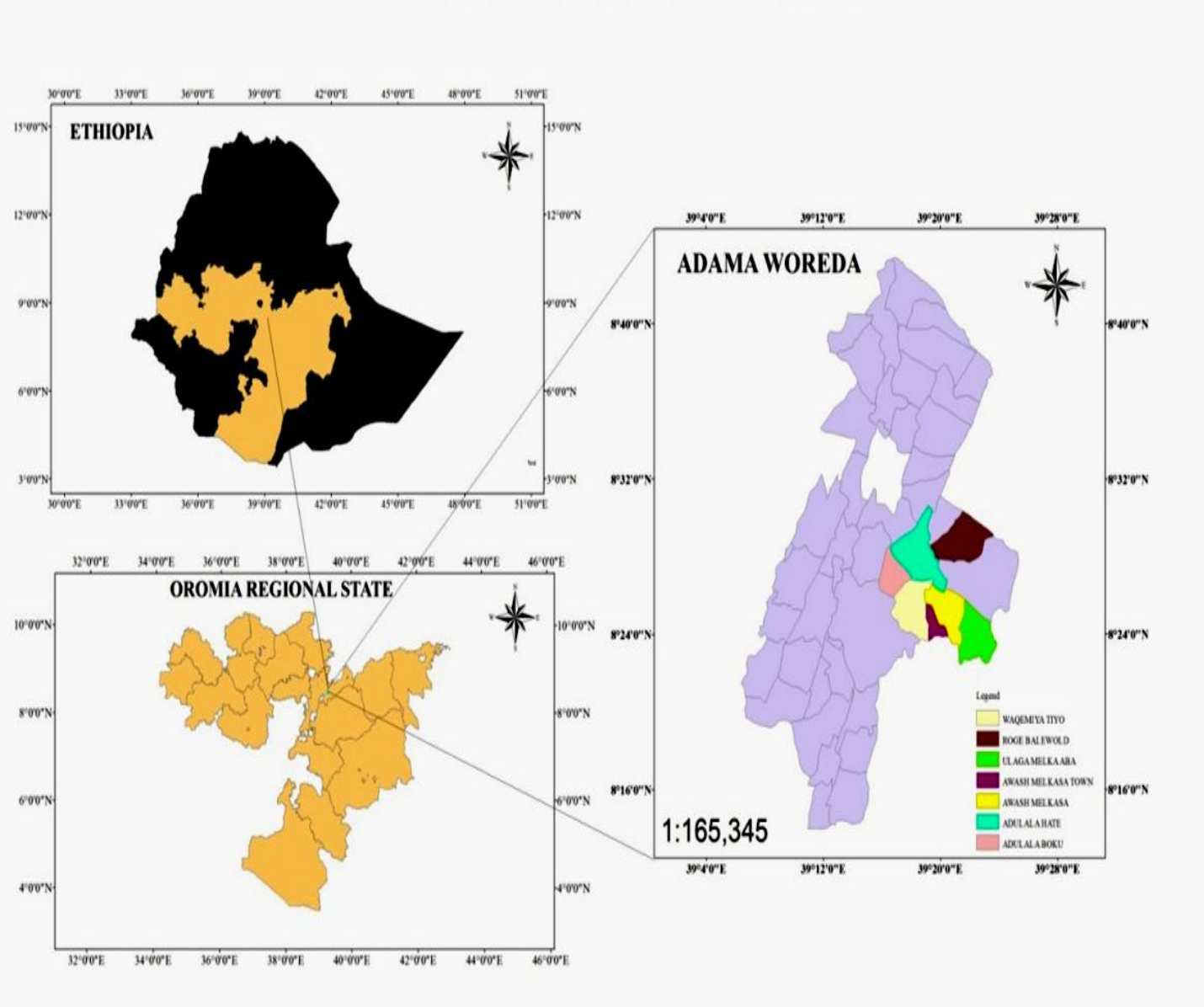

Figure 1.Map of the study area

Source: ARC. GIS Version 10.2. by Dagim Tesfaye

3.1.2. Soil types

Androsol of volcanic origin**,** which is moderately fertile sandy, sandy clay, sandy silt, sandy loam, and silt loam, with pH ranging from 7 to 8.2.

3.1.3. Climate

The climate here is tropical which is classified as Aw by the Koppen-Geiger system of climate of the world. The study area has bimodal rainfall with the very important long summer rainy season

(June-September) and the short rainy Spring-Autumn season (February-Mid-April).There is a difference of 204 mm of precipitation between the driest (December) and wettest (August) months (Fig. 2).

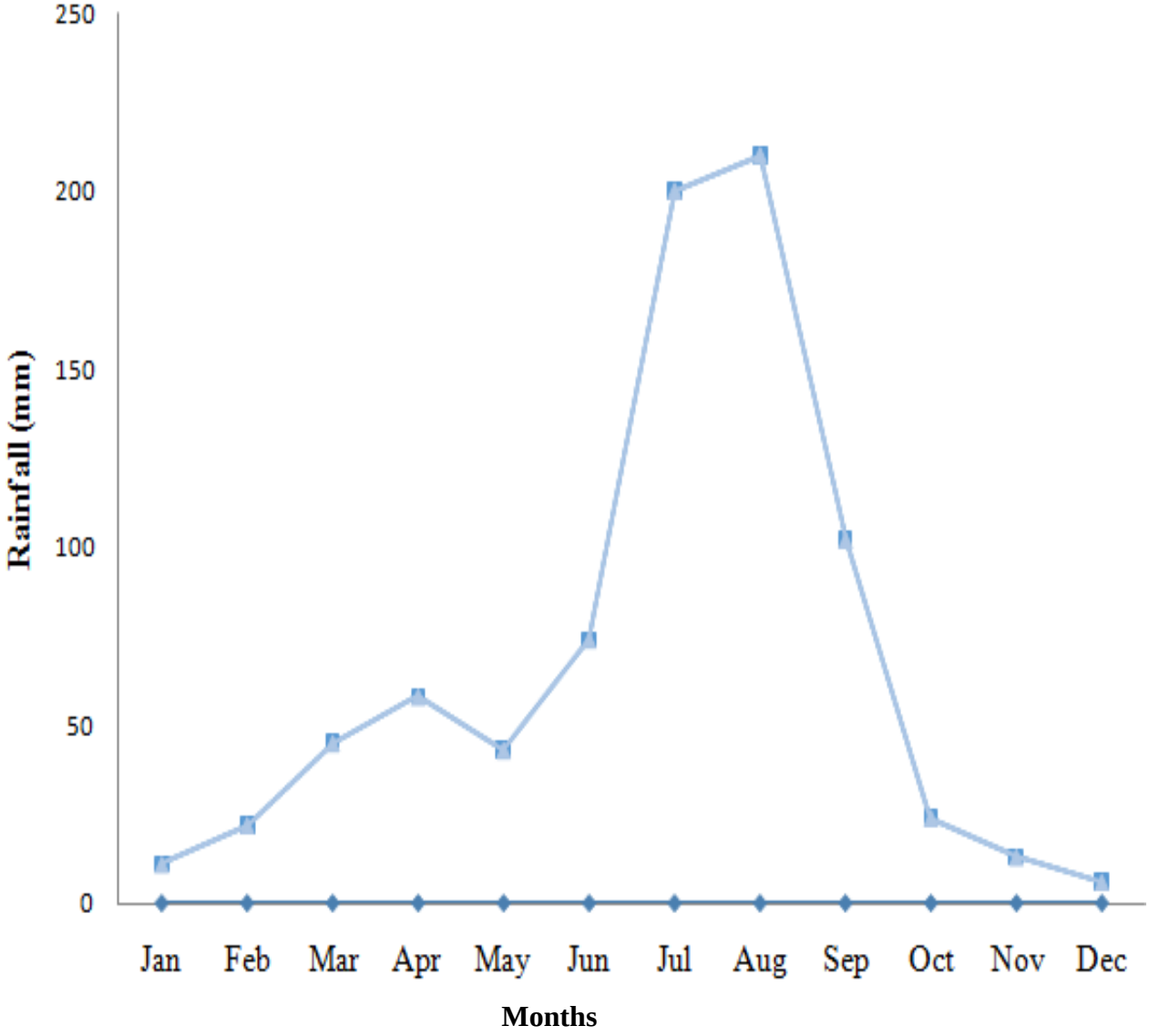

Figure 2. Five years average annual rainfall of Adama Wereda (2012-2016)

*Soucse***:** Eastern and central Oromia Meteorological Service Center

The average maximum and minimum temperature of the study area is 23.89^{0}C and 19.64^{0}C, respectively. The hottest and the coldest months of the year are May, with temperatures averaging 23.89^{0}C and December, with temperatures averaging 19.64^{0}C (Fig. 3).

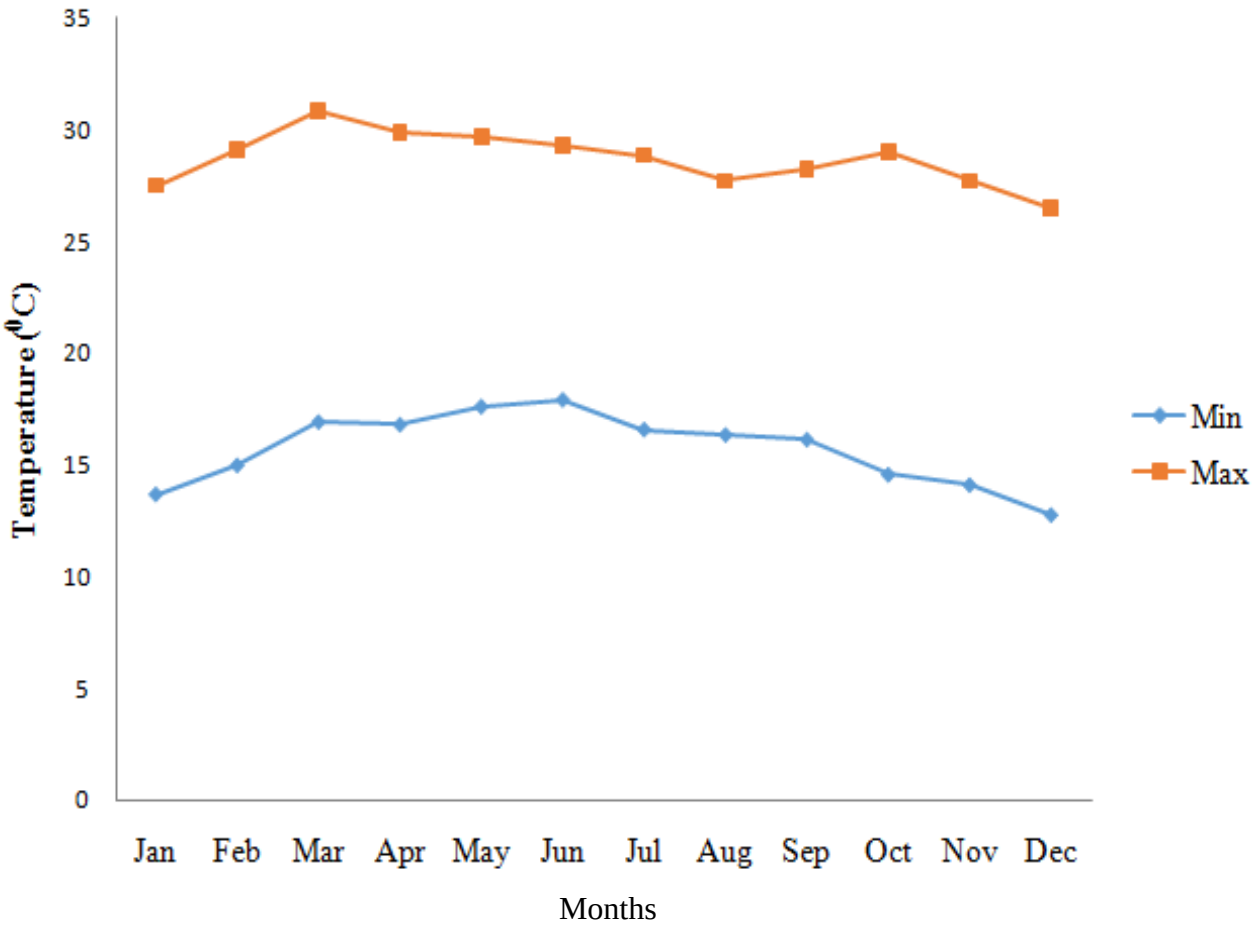

Figure 3.The five year average maximum and minimum temperatures of Adama Woreda.

Source: Eastern and central Oromia Meteorological service center

3.1.4. Vegetation

The major natural vegetation of the study area is characterized by grassland (grazing areas), small or scattered forests containing mainly acacia trees, such as *Acacia saligna*, *Acacia senegal* and *Acacia albidia* and shrub species. The large part of the study area is covered with agricultural farm lands. The most common types of crops cultivated in the study area are crops as maize, haricot bean, millet, sugar cane, wheat, chick peas and teff. Also varieties of vegetables as salad, cabbage, tomato, onion, sweet potato, and some fruits such as papaya are cultivated and harvested in large amount using Kiremt rain, as well as by irrigation using Awash River.

3.2. Methods

The distribution status and impact of *Parthenium* weed on the selected area and environment was studied using different data collection methods. These methods were field observation, data collection from field quadrants, allelopatic effect from field experiments, and document analysis. The study was conducted from September 2016 to July 2017. That means it includes spring, winter, and autumn seasons, which are assumed to be time in which the weed gets flower and bear seeds and spread out by different agents.

3.2. 1. Data collection

The data were collected from purposively selected seven kebeles around Awash Melkasa in Adama woreda, which are infested by *Parthenium* weed. This was made in the months of October and November which are part of spring season and the study will include selected kebeles which are the focus of this research investigation. September to October are months for *parthenium* weed to flower and bear seeds. March to June is time for germination and seedling in accordance of growth calendar of *Parthenium* plant in East Ethiopia (Zelalem, 2013). Thus, there was good opportunity to just collect research data since the weed found almost all time in the research fields.

3.2.2. Sampling techniques and sample size

As to the sampling technique, seven kebeles of Adama Woreda around Awash Melkasa were purposively selected, which were infested by *Parthenium* weed. To collect the vegetation data depending up on the ecology of *P. hyterophorus* transect survey method was employed (Wittenburg *et al*., 2004) in a 50 m distance to lay a quadrat. Sixty three quadrats (nine from each kebele), around agricultural lands, grass lands and bush area each measuring 1 m x 1 m(1 m^2) area, were laid in order to study dispersion rate and impact of this weed on the surrounding agricultural crops and native vegetation.(Fig. 4)

Figure 4.Measuring *parthenium* distribution: laying a line transect (A) counting the weed in a quadrat(B).(photo by Wendosen Adulala Boku site)

3.2.3. Experiment on the impact of *Parthenium* compost on crop plants.

To investigate the impact of *Parthenium* allelopathy, the weed was collected from the environment and ordinary *Parthenium* compost was prepared from the whole plant parts (root, soot and flower). The effect was studied between experimental group (with *Parthenium* compost) and control group (without *Parthenium* compost) on teff (*Eragrostis tef*), maize (*Zea mays*) and haricot bean (*Phaseolus vulgaris*).

Materials and procedure

Materials: Ordinary *Parthenium* compost, selected teff , maize and haricot bean seeds, field plot, meter or ruler, water, plastic pot etc.

Procedure: The experiment was conducted in open field at environmental temperature. The rate of elongation of the seedlings or shoot growth of all crops was evaluated. All experiments were conducted twice in replicates and the average data was used for analysis. The data obtained from the experiment were analyzed using appropriate statistical approaches.

The field plots for teff, maize and haricot bean for both experimental and control groups were prepared on 1.5 m width x 3 m length (4.5 m^2) area. Regarding maize and haricot bean, the experiment was conducted on 60 maize plants (30 for each group), while for haricot bean it was

conducted on 52 haricot bean plants (26 for each group).The compost was applied to the experimental group of all crop plants after germination and the technique spot application was employed for maize and haricot bean(Fig. 5)

Figure 5:*Parthenium* compost (A), its spot application(B) (Photo by Abbi at field experiment May 2017)

After the teff, maize and haricot bean were sowed, every day at evening both experimental and control groups were watered enough amount of water (Fig. 6A). In intervals of seven days, the height of both experimental and control group of plants were measured in centimeter (cm) and was recorded on a notebook for eight weeks or two months for teff and maize, while six weeks for haricot bean (Fig. 6 B)

Figure 6. Watering crops everyday (A) and measuring the height of plants(B) (Photo by Fikadu, June 2017)

The percentage toxicity and the tolerance index of the seedlings of teff, maize and haricot bean due to *Parthenium* compost treatment were calculated from the result measured.

Percentage of toxicity due to *Parthenium* compost treatment was calculated by the formula suggested by Chiou and Muller (1972) as follows:

$$\textit{Phytotoxicity (\%)} = \frac{\textit{Shoot length of control} - \textit{shoot length of treated}}{\textit{Shoot length of control}} \; \textit{X 100}$$

Tolerance index was calculated by the formula suggested by Turner and Marshal (1972). Longest shoot in treatment of the seedling was measured for the calculation of TI as follows:

$$\textit{Tolerance index (TI)} = \frac{\textit{Longest shoot in the experimental group}}{\textit{Longest shoot in the control group}} \; \textit{X 100}$$

Variables of the experiment

Variables are important parts of science projects and experiments. Basically, a variable is any factor that can be controlled, changed, or measured in an experiment. Scientific experiments have several types of variables, such as:

- **Independent variable** is the one condition that is manipulated or changed by the experimenter to investigate its effect on the dependent variable. In this experiment, the independent variable is the presence or absence of *Parthenium* compost,
- **Dependent variable** is the variable that the experimenter measures or observes and is dependent on the state of the independent variable. In this experiment, the dependent variable is plumule or stem height growth of teff, maize or haricot bean.
- **Controlled variable** is a variable that should be kept constant or do not change during the experiment. The controlled variables in this experiment, include amount of water added, soil type etc.
- **Extraneous (confounding) variables** are" extra" variables that can't be controlled and may influence the outcome of the experiment.

3.2.4. Measuring soil pH and moisture content.

Field procedure

Soil sampling:-sampling was carried out in the April of 2017 after a general visual field survey of the area was carried out to have a general view of the variations in the study area. Representative soil sampling sites were then selected based on vegetation cultivation history. During soil sampling sites selection, the main factors affecting soil sample were considered. Following the general site selection twenty one representative fields for each case were selected, from sample sites Adulala hate, Awash Melkasa town, Awash Melkasa, Ulaga Melka Aba, Roge Balewold, Waqmey Tiyo and Adulala boku respectively. After the sites are specified, a total of fourteen samples were obtained from each kebele at the depth 10 inches for two soils by using an auger (Benjamin, 1992). The samples were sieved, weighed and stored in polyethene bags (Fig. 7).

Figure 7. Soil moisture and pH: Taking soil sample using auger (A) and measuring the weight in the field (B).(photo by Wedosen during data collection ,May 2017).

Parameters studied

Physical analysis (soil moisture content) and chemical analysis(soil pH) of *Parthenium* boundd and non-*Parthenium* bound soils were investigated and calculated.

3.2.5. Data Analysis

Diversity of the species for the vegetation data from the sample sites in the study areas were compared using Simpson's Diversity index, (1949). This index accounts both for the abundance and evenness of the species in natural environment as shown by the equation below. It is also used to assess the impact of *Parthenium* on the diversity of herbaceous plant species. The higher value of index of diversity indicates the variability in the type of species and heterogeneity in the community where as the lesser values point to the homogeneity in the community.

Simpson's Index: $\mathbf{D = 1 - \sum pi^2}$

Where:

D= ranges from 0 to 1

N= total number of all species.

Pi = proportion of each species (n/N)

n= total number of each species

Simpson's Index of Diversity=1-D –Ranges from 0 to 1 low to high diversity

Descriptive statistics such as means, percentage and frequencies were used to summarize the information. Also the effect of *P. hysterophorus* on plant height was analyzed by SPSS computer software program to calculate some statistical data like mean value in order to evaluate data collected from field plots, if appropriate.

To investigate soil pH, 25mL of deionized water (pH 7.0) was added to 10g of soil sample (1:2.5 ratio) and mixed thoroughly. Then after the instrument was standardized with acidic (pH=4.2), neutral (pH= 7.2) and alkaline(pH =9.2) buffer solution and the pH was directly measured using software Stat 8. Then the effect of *Parthenium* on soil pH was compared between *Parthenium* bounded and non-*Parthenium* bounded of soil sample.

To calculate percentage of moisture content, soil samples were weighted in the field at the time of collection. The sample were brought to the laboratory and dried in the oven at temperature of 105^0C. Gravimetric method was used for moist analysis. This method involves drying the soil until a constant weight is obtained (Jackson, 1973). Since the wet samples were measure in the field, the dried weight was measured after a constant weight was obtained and is calculated as:

$$Moisture\ \% = \frac{Loss\ in\ wt\ on\ drying\ (g)}{Initial\ sample\ weight} \times 100$$

4. RESULTS

4.1. Distribution Status and Impact of Parthenium

4.1.1. *Parthenium* distribution

The *Parhtenium* infestation level in each sample sites (Waqmay Tiyo, Roge Balewold, Adulala boku, Adulala hatie, Awash Melkassa town, Awash Melkasa and Waga Melka Aba) was investigated by laying a line transect and counting the weed in each quadrat. The result obtained from quadrat measurement from the study sites is shown bellow (Table 1 & Plate 1).

Table 1 *Parthenium* infestation level in the sample sites of the study area

No	Sample site (Kebele)	No of *Parthenium* weed				Total number of other herbaceous plants			
		Site1	Site2	Site3	Mean	Site1	Site2	Site3	Mean
1	Waqmey Tiyo	31	43	21	31.6	29	37	19	28.3
2	Roge Balewold	45	73	54	57.3	38	23	14	25
3	Adulala Boku	62	51	58	57.0	18	12	13	14.3
4	Adulala hatie	67	78	84	76.3	19	27	15	20.3
5	Awash Melkasa town	18	26	23	22.3	39	46	43	42.6
6	Awash Melkasa	13	9	14	12	24	36	28	29.3
7	WagaMelka Aba	43	51	46	46.6	37	21	21	26.3

The result from diversity study is the diversity index of 0.49. D=1- $\sum pi^2$, where D, Simpson index of diversity, pi, proportion of each species (Table 2)

Table 2. Diversity of *Parthenium* and other herbaceous plants in the study area

Species	Number (n)	Pi (n/N)	Pi^2	$\sum pi^2$	$D=1-\sum pi^2$
Herbaceous plants	26.58	0.38	0.14	0.51	0.49
Parthenium Weed	43.30	0.62	0.37		

4.1.2. The Effect of *Parthenium* compost on selected crops

To investigate the allelopatic effect of *Parthenium,* the weed was collected from the environment and ordinary *Parthenium* compost was prepared. The effect of *Parthenium* allelopathy was studied on experimental group of teff, maize and haricot bean. The effect of *Parthenium* compost on Teff (*Eragrostis tef*) and Maize (*Zea mays*) grown for about eight weeks were considered in this study, while the haricot bean was grown for about six weeks.

According to the result from the field plots; the mean height in cropping season of teff (*Eragrostis tef*) of the experimental group and the control group was measured in interval of seven days (Table 3 & Plate 2).

Table 3 The effect of *Parthenium* compost on the height of teff (*Eragrostis tef*)

Time (week) and date	Experimental group(with compost)	Control group (without compost)
1 (30/04/17)	1.67± 0.24	1.16± 0.24
2 (07/05/17)	4.26± 0.24	4.67± 0.47
3 (14/05/17)	7.67± 0.47	10.67± 0.47
4 (21/05/17)	25.33± 0.94	35.00±2.16
5 (28/05/17)	40.33± 1.25	51.33±1.25
6 (05/06/17)	48.33±2.05	59.67±1.25
7 (12/06/17)	61.00± 0.82	72.00± 0.82
8 (19/06/17)	65.33± 0.48	76.67± 0.94

Regarding (*Zea mays*), the mean height of the experimental group and the control group in cropping season was measured in interval of seven days (Table 4 & Plate 3)

Table 4. The effect of *Parthenium* compost on the height of maize (*Zea mays*)

Time (week) and date	Experimental group	Control group
1 (30/04/17)	2.5 ±0.5	2.5 ±0.5
2 (07/05/17)	8 ±1	7 ±1
3 (14/05/17)	13 ±1	12 ±1
4 (21/05/17)	17.6 ±2	16 ±2
5 (28/05/17)	31.33 ±4.66	25.3 ±2.7
6 (05/06/17)	46.3±7.7	36.3 ±3.7
7 (12/06/17)	96 ±2	67 ±2
8 (19/06/17)	150 ±10	115 ±5

In the study, at the end of sixth week the mean height of haricot bean (*Phaseolus vulgaris*) of the experimental and the control group was measured in interval of seven days and five of the plants from the experimental were died (Table 5 & Plate 4).

Table 5. The effect of *Parthenium* compost on the height Haricot bean (*Phaseolus vulgaris)*

Time (week) and date	Experimental group (with compost)	Control group (without compost)
1 (14/05/17)	0	0
2 (21/05/17)	5±1	5±1
3 (28/05/17)	16.3±1.7	20±2
4 (05/06/17)	33.6±0.4	53±3
5 (12/06/17)	63.5±0.3	90 ±5
6 (19/06/17)	80±10	120±10

The shoot growth parameters, tolerance index and percentage toxicity due to *Parthenium* compost treatment of teff, maize and haricot bean were calculated and listed as shown bellow (Table 6).

Table 6. The tolerance index and percentage toxicity of selected crops due to *Parthenium* compost treatment

Selected Crop	Longest shoot (control)	Longest shoot (treated)	Tolerance index (TI)	% of toxicity (Phytotoxicity)
Teff (*Eragrostis tef*)	76.67 cm	65.33 cm	84.61	14.79
Maize(*Zea mays*)	115 cm	150 cm	130.0	-30.43
Haricot bean(*Phaseolus vlgaris*)	120 cm	80 cm	66.6	33.33

4.1.3 Soil moisture and soil pH

The measured soil pH of the *Parthenium* bound soil was in the range of 7.43 to 8.34, while the non-*Parthenium* soil pH was in the range of 7.02 to 8.47, and moisture percentage of the *Parthenium* bound soil was also in the range of 12.83% to 31.78%, while that of the non-*Parthenium* bounded soil was in the range of 10.99% to 31.01% (Table 7).

Table 7. The mean results of soil moisture content and soil pH from different soil samples.

No	Sample site	% Moisture PBS	%Moisture NPBS (control)	pH(H_2O) PBS	pH (H_2O) NPBS (control)
1	Roge Balewold	25.78	23.318	7.43 ± 0.313	7.02± 0.213
2	Waqmey Tiyo	24.03	23.04	7.621 ±0.22	7.248 ±1.72
3	Adulala Boku	31.78	31.01	7.79 ±2.00	7.48 ±2.37
4	Adulala hatie	14.63	15.13	8.29± 2.31	8.06± 1.53
5	Awash Melkassa town	12.83	10.99	8.113± 3.22	7.83± 1.62
6	Awash Melkasa	17.94	17.14	8.34 ±271	8.472 ±1.52
7	Waga Melka Aba	25.78	25.36	7.982± 2.41	7.672± 1.92

PBS-*Parthenium* bounded soil NPBS- Non- *Patrhwnium* bounded soil

5. DISCUSSIONS

P. hysterophorus has become major invasive weed of various areas of Ethiopia in a relatively short period of time. The result of this study revealed this fact in the east Shoa zone Awash Melkasa area.

The result of this study showed that the *Parthenium* diversity was higher in the study area than other herbaceous vegetation with D =0.49. Hence, the infestation level of the *parthenium* weed in the study area was high. The lesser values of index of diversity indicate the homogeneity of the weed in the study area. This study confirmed that the area is dominated by the weed and spread at a higher rate that might be because of its invasive nature. In general *P. hysterophorus* infestation is high compared to other herbaceous vegetations.

According to, the result, in Adulala hate, Adulala Boku ,Roge Balewold, Waga Melka Aba study sites there was a difference between *Parthenium* weed and other herbaceous plants, which mean the infestation level of the *Parthenium* weed was high. In Awash Melkasa, Awash Melkassa town and Waqmey Tiyo study sites compared to other herbaceous plants the infestation level was medium.

The result of this study goes in line with the study of Sakai *et al*. (2001) and Kohli *et al*. (2004), where invasive plants are known to exert significant impact on the natural communities as they cause their displacement and hence exert imbalance in the natural and agricultural ecosystem. This imbalance causes the formation of large monoculture of invasive plants in the alien environment. The weed affects not only the species diversity of the native areas, but also their ecological integrity. Moreover, environmental degradation and disturbance favors the invader species such as *Parthenium* weed. Under such circumstances the weeds easily establish themselves in the sites and start interfering with other native species by suppressing their potential growth and biomass production.

Similarly the study of Oudhia (2000), supported this finding in that because of its efficient biological activity and adaptability to the varying soils and microenvironments, *Parthenium* weed has a tendency to replace the dominant flora in wide range of habitats cutting across state boundaries and agro- climatic regions. In the study area around Awash Melkasa limited species can be seen in *P. hysterophorus* dominated area in recent years and during the study period in

particular. Hence, the weed poses a pressure and replaces most indigenous natural flora from the area and become a strong threat to biodiversity.

Niguse and Kifle (2016), also reported that, despite the awareness of the community about *Parthenium* weed, the rate of infestation in east Shoa and west Arsi zones is increasing from time to time, this might be because of proper action was not done by different stakeholders. In addition, the communities were not mobilized to take action on the weed. According to the study conducted by Taye (2007) extensive infestation in the central farmlands of east Shewa, Dukem, Bishoftu, Modjo and Koka areas has been prevailed.. Belachew and Tessema (2015), also reported from their study that, *Parthenium* is widely spread in the range lands and in the cultivable fields of East Showa Zone of Boset district. The same situation was observed in Awash Melkasa, where most of studied sites are under the influence of *Parthenium* weed.

The study also tried to use the *Parthenium* weed in the form of ordinary compost to grow crops such as Teff (*Eragrostis tef*), Maize (*Zea mays*) and Haricot bean (*Paseolus Vulgaris*). The result of *Parthenium* weed compost in the field plot experiment showed that, the growth rate of both teff and haricot bean was affected, whereas that of maize was improved. Regarding the tolerance index and percentage of toxicity of the crops due to *Parthenium* compost treatment, the result of this study revealed that the maximum tolerance index was observed in maize,(130) followed by teff (85.2) and the minimum was observed in haricot bean (66.6). The highest phytotoxic effect was observed on haricot bean (33.33%) and then on teff (14.79%) and the minimum was observed on maize (-30.43%).

During the first week of germination of teff of the experimental group was better than the control group. Thereafter the growth rate of the teff went very slow in the experimental group and the control group grew better than the mean height of teff of the experimental group. Similarly, Tadelle (2002) reported that the aqueous extracts of *P, .hysterophorus* from leaf and flower inhibits seed germination and sometimes causes complete failure of seed germination of teff (*Eragrostis tef*).

The result from the field plot experiments also reveal that the growth rate of haricot bean of the control group was higher than the experimental group. This is in agreement with the results of Netsere and Mendesil (2010), aqueous extracts of *Parthenium* flower at all concentration levels(5%, 10% and 15%) and leaf at intermediate and higher concentration levels induced the

highest allelopathic effects as indicated by complete failure of germination and seedling growth of haricot bean and soya bean.. Tahseen *et al*.(2015), also concluded from their experiment that, haricot bean (*P. vulgaris*) was more sensitive to leaf, stem and flower extracts of *P. hysterophorus*. This showed that ordinary *Parthenium* compost has sufficient amount of parthenin and phenolics as the allelopathic agents, which inhibit the early growth and development of the crops.

The result of this study also revealed that the consistent mean height of the experimental group of maize was significantly greater than the control group. The experiment done by Satish *et al*. (2016), also revealed that, although some work has already been carried out on composting of *Parthenium hysterophorus* weed but it is not generally practiced, compost prepared from the weed by this method gave good germination of maize as well as growth of the plants. This is supported by the fact that no *Parthenium* plant was germinated after application of compost, which may also encourage users about its composting.

Similarly Javaid, (2008), used *P. hysterophorus* weed as green manure for maize and mung bean production. The highest root and shoot biomass in maize was obtained in 3% green manure treatment, which was significantly greater than that obtained in the control and equivalent to that obtained in the NPK fertilizer treatments. The effect of *P. hysterophorus* green manure and effective microorganisms and bio fertilizer, on wheat (*Triticum aestivum*) cultivation was studied. Highest root biomass was recorded in 3% green manure-amended treatment. Spike length, number of grains per spike and grain yield gradually increased by increasing the quantity of green manure. There was 43-253% increase in grain yield over control due to various green manure treatments as compared with 96% increase due to NPK fertilizers over control.

Ambasta and Kumari 2013, reported that, if *Parthenium* compost was prepared by scientific means, it could support germination of dormant seed. It also improves soil-texture and fertility without affecting soil health. For maximum exploitation of the nutrient contents of *P. hysterophorus*, without incurring the ill effects of phenolics, novel compost procedure had been tried by many researchers. This milli-compost (MC) is more effective than ordinary *Parthenium* compost (OPC). So, if tapped properly, this weed can contribute to soil fertility and soil pH stability there by better yield and agricultural productivity could be obtained.

Wakjira *et al*.2009, suggested that, composting *Parthenium* before flowering might be the way to minimize its allelopathic inhibition potential and usability as compost. Therefore, resource poor farmers could make use of the high nutrient contents of *Parthenium* compost and could control *Parthenium* by composting if the package is provided to them.

The soil moisture and pH were considered in this study on *Partenium* bound and non-*Parthenium* bound soil. The result revealed that, soil moisture contents of *Parthenium* bounded were found to be within the range of 12.83 %-31.78 %, was higher than non- *Partenium* bound, which was within the range of 10.99 % - 31.01 % and the measured soil pH of the *Parthenium* bound soil was in the range of 7.43 to 8.34, while the non-*Parthenium* soil pH was in the range of 7.02 to 8.47.

Samples of soil taken from the study area showed that the moisture percentage was slightly higher in *Parthenium* bounded soil, as compared to the non- *Parthenium* bounded ones. This difference might be observed, due to the weed cover the soil that reduces water loss and improves soil texture. Similarly El–Ghareeb (1991), in his study demonstrated that besides the growth inhibitory effect of *Parthenium* weed on other plants, the soil moisture significantly higher in his study site.

Ambasta and Kumari (2013), similarly stated that *P. hysterophorus* is a rich source of N, P, K, Ca, Mg and chlorophyll content and is ideally suited for composting which is two times more than Farm Yard Manure (FYM) .For this reason, *Parthenium* compost aids in moisture conservation which is utilized for better root penetration and crop growth. This enhancement attributed to the higher water holding capacity of the soil due to the influence of organic waste application. The moisture in soil due to application of *Parthenium* compost was 14.5 and 16.5% at 0-15 and 15-30 cm depths as compared to 10.7 and 11.6% at 0-15 and 15-30 cm depths of soil due to application of NPK alone.

In addition, the result of the study showed that the mean value of soil pH of *Parthenium* bounded soil is higher than non *Parthenium* bounded soil. Significant differences are observed in the soil pH between soil samples of *Parthenium* bounded and non-*Parthenium* bounded for Roge Balewold, Adula Boku, Adulala hatie, Awash Melkasa town and Waga Melka Aba kebeles while in Awash melkasa kebele non–*Parthenium* bounded soil has higher pH than *Parthenium* bounded soil. Similarly Bizwana *et al.* (2006), in their study demonstrated that, soils collected

under *Parthenium* at the different depths show an overall higher pH value than those under other herbaceous plants.

Abundant evidences support the idea that higher resource availability increases the susceptibility to invasion of plant communities. Further the absorption of phenolics and the allelopathic compounds by soil particles and their microbial breakdown may account for the outcome of present observations, which are further affected by various soil factors such as soil moisture, soil texture, organic carbon and organic matter etc. The work of Maron and Connor (1996), Dalton (1999), Huang *et al*. (1998) and Kobayashi (2004), are also in agreement with this finding.

According to the findings of this study, ploughing the fields before its maturation and production of seeds, manual uprooting before flowering and seed setting, using of chemicals and mainly composting of *Parthenium* scientifically are the controlling mechanisms of the weed. Similarly, Bhan *et al*. (1997), described that manual and mechanical control methods give temporary results because *P. hysterophorus* covers large areas and they also stated that no single method of *P. hysterophorus* control has been proved satisfactory as each method suffers from one or more limitation such as inefficiency, high cost, impracticability, environmental safety and only temporary relief. Tamado (2001), also reported that use of clean seed, more competitive variety and choice of an appropriate sowing rate and date are used to control the impact of the weed.

In general, there has to be a means to control invasion of the weed like *Parthenium* from farm lands or the way to introduce packages to process and use the weeds to add soil fertility. The study done by Mohammed (2010) showed that some of the preventive methods that restrict the entrance of weed seed into a non- infested area are uprooting of the weed before flowering and seed setting. They indicated it as the most effective and less costly strategy to manage *Parthenium*. Also composting *Parthenium* before flowering is a means to minimize its allelopathic inhibition potential and one way of management by utilization. Similar suggestion was given by Australian Weeds Committee (2012), effective broad scale management of *Parthenium* weeds requires an integrated approach that includes prevention and eradication programs, establishment and implementation of management zones, and the protection of key environmental, social and economic assets in areas where the weeds are already widespread.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

Parthenium hysterophorus is an invasive alien weed growing in farmlands, roadside, grazing lands and gardens. It can germinate and produce seeds throughout the year and can cause a serious problem in biodiversity. In addition *Parthenium* weed has the ability to utilize the opportunity of drought prone period in the area to use the chance where the indigenous plants deteriorate and leave much bare ground cover. *Parthenium* weed establishes its weed monoculture on the bare grounds and gradually weakens even the survival of drought tolerant herbaceous plants.

This study tried to reveal that the infestation level of the weed is increasing from time to time and its effect on the biodiversity is increasing at an alarming rate. This shows that there was no much effort done by all responsible bodies, as this, noxious plant grows in a wide variety of habitats and causes changes in above ground vegetation as well as in below ground soil nutrients as indicated in this findings. It is capable of out- competing native and non- native plants that are important to livestock. This implies that any intervention intending to control weed should take into consideration of the ability of *P. hysterophorus* to grow at every season of the year.

In addition, this study tried to evaluate the impact of *Parthenium* weed compost on growth rate of selected crops. The result of *Parthenium* weed composition in the field plot experiment showed that, the growth rate of the teff and haricot bean is affected, whereas that of maize was improved. In the present situation the growth, particularly, of teff and haricot bean is affected by weed *Parthenium*. Thus, appropriate measure for management of such weed in Ethiopia is becoming mandatory, because teff and haricot bean are the most cultivated crops throughout the country in general, Awash Melkasa in particular.

6.2. Recommendations

This study focuses on the distribution status and impact of *P. hysterophorus* on teff, maize and haricot bean growth. This is a piece of finding which could be a baseline study for further investigations on the effect of *Parthenium hysterophorus* in particular. Based on the investigation, the following recommendations were suggested:

- Integrated effort should be practiced to control *P. hysterophorus* till the complete seed bank is exhausted because of its high and continuous seed production ability throughout the year.
- Awareness should be created to the residents in the infested areas particularly to farmers on the negative impacts of *Parthenium* weed on productivity of plants and its effect on biodiversity.
- Joint projects should also be formulated to prevent and control the danger of *P. hysterophorus* in regional level the weed is aggressively spreading to the crop yielding areas of the country.
- Simplified technology packages for bio-composting of *Parthenium* weeds should be adopted and practiced.
- *Parthenium* weed resistant varieties of crops should be selected and distributed to the farmers.
- Biological controlling mechanisms, agents and competitive plants should be used in an integrated manner to achieve better management of *Parthenium* weed.
- By using its potential beneficial effects as opportunity there is a possibility to eradicate this weed through time.

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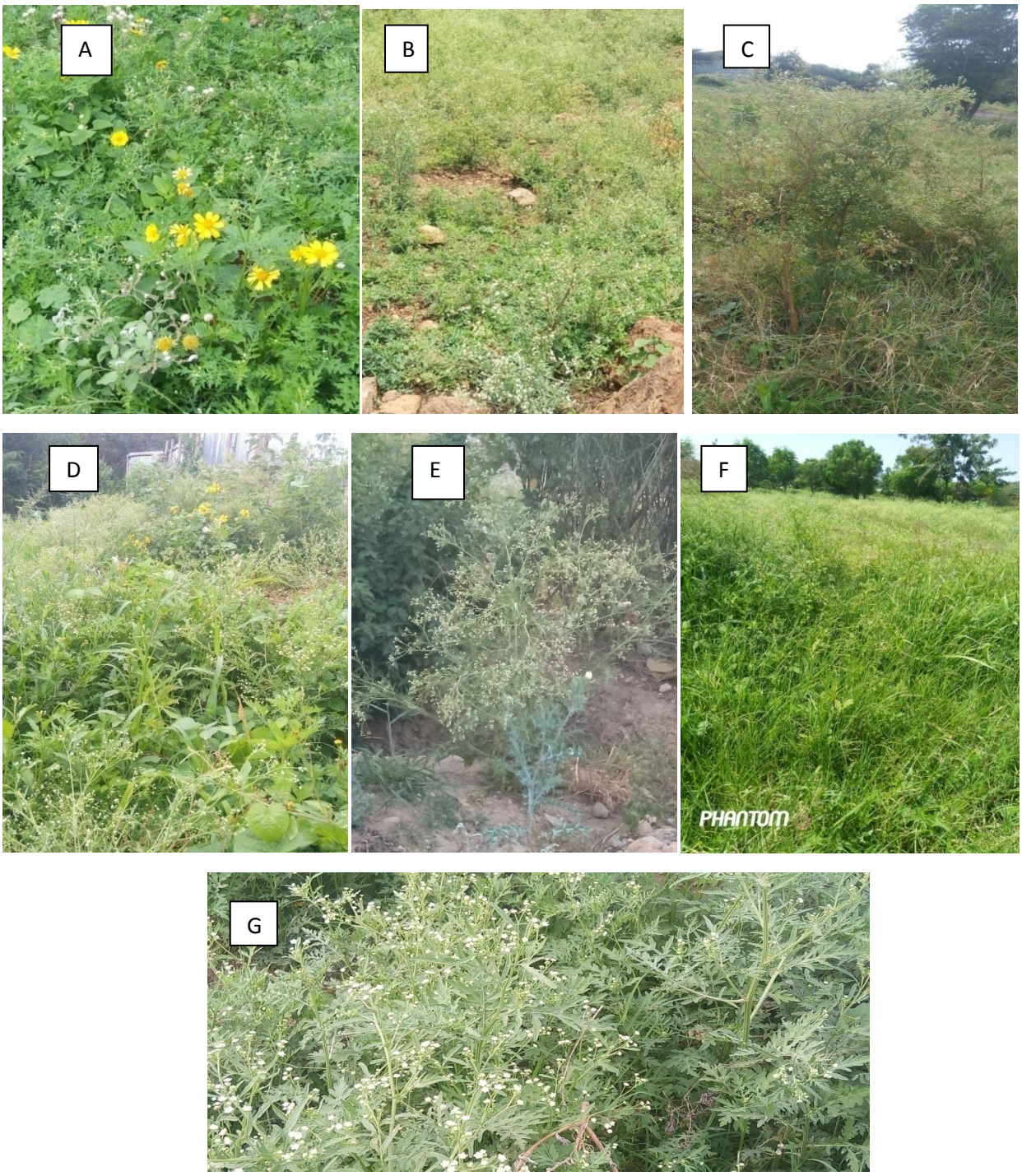
PLATES



Pla te 1.Infestation of parthenium weed in the study area: garden (A), farm lands (B), range lands (C) neglected urban sites (D)disturbed areas(E)Grazing lands(F) school garden(G): (Photo by Million Awash Melkasa, 2017).

Plate 2 Field experiment on teff(*Eragrostis tef*) (Awash Melkasa, 2017)

Plate 3. Field experiment on Maize(*Zea mays*) (Awash Melkasa, 2017)

Plate 4:Field Experiment on haricot bean(*Phaseolus vulgaris*) (Awash Mekasa,2017)