Allelopathic Potential of Niger (*Guizotia abyssinica* L.) on *Parthenium hysterophorus* Seed Germination and Seedling Growth

Habtamu Ashagre¹*, Teferi Tolesa² and Ibrahim A. Hamza³

¹ College of Agriculture and Veterinary Sciences, Ambo University, P. O. Box 19, Ambo, Ethiopia.
² Elfeta District Agricultural Office, West Shewa Zone, Oromia National Regional State, Ethiopia
³ School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Nigeria

Accepted 13 December, 2018.

To determine the allelopathic effect of *Guizotia abyssinica* on *Parthenium hysterophorus*, a laboratory experiment was undertaken in Weed Science Research Unit of Plant Protection Research Center, Ambo, Ethiopia. Leaf, root, and stem extracts with 15, 30, 45, 60 and 75 percent levels of concentrations were used for the experiment. Control check was treated similarly with distilled water. The experiment was arranged factorially in a complete randomized design. The results indicate that stem and root aqua’s extracts significantly affect germination percentage, root length, shoot fresh and dry weight, and root fresh weight of *Parthenium hysterophorus* (p<0.05). Thus, the allelopathic effect of *Guizotia abyssinica* on *Parthenium hysterophorus* is concentrated in stem and root of the plant. However, leaf parts extract have less inhibitory effect. Increase in the level of concentration extract significantly reduced all germination and growth parameters of *Parthenium hysterophorus*. Higher concentrations (≥ 60%) have maximum deleterious effect on *P. hysterophorus* seed germination and growth parameters.

**Keywords:** Allelopathy, germination, *Guizotia abyssinica*, *Parthenium*, seedling growth.

**INTRODUCTION**

Niger (*Guizotia abyssinica* L.) is an oil crop largely grown in the highlands of Ethiopian, and it constitutes about 50% of Ethiopian and 3% of Indian oilseed production (Eneyew, 2013). Niger cultivation and consumption are deeply rooted within the Ethiopian culture and the country’s local population highly values the crop. It remains the most popular oil crop for local consumption although it was recently overtaken by sesame with slight margins in terms of production volume in the country (CSA, 2014). Niger is grown mainly from 1,600 to 2,200 m.a.s.l in Ethiopia, but can be cultivated at altitudes as low as 1,200 m.a.s.l and as high as 2,700 m.a.s.l (Getinet and Sharma, 1996). In Ethiopia among oil crops, Niger covers 2.30 % (about 285,303.47 hectares) of the grain crop area and 0.88% (about 2,202,111.90 quintals), of the grain production (CSA, 2014). It is the major source of edible oil that holds significant promise for improving rural livelihoods. In addition, to its oil, Niger offers an important source of seed proteins, carbohydrates, vitamins and fiber that significantly contribute to the human dietary intake (Thatte and Lakshmi, 2012). Niger is also recognized as an effective green manure cover crop (Bulcha, 2007).

*Parthenium* weed is one of the most aggressive invasive species that can cause irreversible environmental and socio-economic impact from species to ecosystem levels (Tamado, 2002). In addition, it has competitive and allelopathic effect on different crops, it poses health hazard to humans and animals (Kololgi et al., 1997). In Ethiopia, *Parthenium* weed has been reported as relentlessly spreading throughout the agricultural lands, forests, orchards, poorly managed arable crop lands and rangelands, and almost throughout the country it became a serious weed (Tefera, 2002; and Tamado, 2002 ).

Weed management with strong interfering smoother crops and plants are recommended as element of integrated

*Corresponding author E-mail: ashagrehabtamu@gmail.com
Parthenium weed management (Tamado, 2002). Allelopathic plants may widely be used in sustainable agriculture for their potential role in herb/weed and insect pest management (Tefera, 2002). Allelopathic plants derived from many crops such as sunflower (Helianthus annuus) and castor bean (Ricinus communis) prevent some broad and narrow leaf weeds growth (Seyyedi et al., 2013). In Ethiopia, farmers often reported that G. abyssinica has suppressing effect on herbaceous weeds and serve as a good precursor for cereals. Inclusion of G. abyssinica in the rotation practice of weed prone areas can be considered as one mechanism of weed management.

Weed management practice in most developing countries include use of synthetic herbicides which are not environmentally friendly, expensive, and not easily available for farmers. Therefore, alternative strategies are required for better weed management at the small holder farmers level. Such alternative strategy includes the use of allelochemicals which are believed to be much safer. Allelochemicals are found in different organs and tissues of plants from where they are released to the soil through the process of leaching, volatilization, root exudation and decomposition of plant residues (Ben et al., 2001). Allelopathic plants compete with other plants, by producing different secondary metabolic components such as alkaloids and glycosides and introducing them to the soil rhizosphere of plants (Jarchow and Cook, 2009). The inclusion of allelopathic plants in crop rotations may have the potential to aid weed control, but identification of the nature and magnitude of allelopathic effects of both traditional and novel break crops is required if opportunities for improved weed control in organic systems are to be fully exploited (Robson et al., 2001). Hence, farmers traditionally used Niger plant as weed smothering crop by involving in the rotation scheme of other crops. This could be due to its vigorous growth and/or allelopathic effect on weed plants. However, there is no information as which crop part and level of extract concentration have major allelopathy effect on parthenium weed. Thus, the purpose of this research was to evaluate the allelopathic effect of Niger plant parts on seed germination and seedling growth of P. hysterophorus weed under in vivo condition.

MATERIAL AND METHODS

A laboratory experiment was conducted to evaluate the effect G. abyssinica plant parts and their concentration on P. hysterophorus at Weed Science Research Unit, Plant Protection Research Center, Ambo, Ethiopia. Fresh local G. abyssinica plant leaf, stem and root at vegetative growth stage were collected from Ambo Plant Protection Research surrounding farmer’s field. The root mud was washed with tap water and risen with deionized water. The growing fresh tissues of leaf, stem and root parts were crushed and grinded with pestle and mortar separately (Kowthar et al., 2011), eighty gram of each grind plant material was mixed in distilled water at 1g/ml ratio, soaked and blended with blender (Oudhia et al., 1999). The mixtures were extracted using 100 x 100rpm centrifuge for twenty minutes. The filtered extracts was poured into 250 ml volumetric flasks, well covered by aluminum foil and preserved in refrigerator set to -5°C. Ten percent filtered extracts was taken from 70ml stock solution for each plant parts. Five different concentrations 15, 30, 45, 60 and 75% were prepared for each plant parts. Ten sound seeds of P. hysterophorus were sown on a filter paper in a 12cm diameter sterilized Petri dish. The filter paper was moistened with (10ml) aqueous extract of leaf, stem and root extract of G. abyssinica plant with the respective concentration in 48hrs. Control check was treated similarly with distilled water. The treatments were arranged using Complete Randomized Design with three replications. The Petri dishes with treatments were incubated at 25°C for 15 days. Data on germination% and germination rate was recorded within day interval until the final as described by Ellis and Roberts (1981). Seedling length and fresh weight were taken directly by using ruler and sensitive balance, respectively after the seedling root and shoot separated by scissor. The data on dry weight was recorded after root and shoot dried by oven dry for 48hr at 70°C, and the collected data were analyzed and tested using SAS version 9.

RESULT AND DISCUSSION

Germination percentage and rate

The analysis of variance showed that aqueous extracts of G. abyssinica root, stem and leaf significantly (p<0.05) affect the germination percentage of Parthenium seeds (Table-1). Maximum seed germination (62.2%) was achieved for the leaf and the minimum (51.667%) was found for the stem extract of G. abyssinica. This indicated that stem extract of G. abyssinica was having relatively more inhibitory effect on germination percentage than corresponding leaf extract. There was no significant inhibitory difference among G. abyssinica plant part (root, stem and leaf) aqueous extracts on the germination rate of Parthenium (p<0.05). In general, all plant parts affect equally the germination rate of the Parthenium seed. In line with these results, Modupe and Joshua (2013), announced that among extracts obtained from different sorghum plant parts, stem comprise maximum effects in preventative property on Euphorbia heterophylla weed seeds germination.

Germination of P. hysterophorus seeds were adversely affected by aqueous extracts of G. abyssinica (Table-2). However, germination response of P. hysterophorus seed varied with the levels of concentration.
All extracts negatively affect the germination of *P. hysterophorus*, when compared with the control. Niger aqua’s extract with 60 and 75% inhibited the germination of *P. hysterophorus* seed by 59% and 90%, respectively. There was no significant difference among 15, 30, and 45% treatments on germination rate; nevertheless increase ≥ 60% in concentration of aqua extract significantly affected growth parameters. The decrease in germination rate may be due to the slowdown of living processes of the plants caused by the loss of seeds respiration resulted by chemicals (Rezaee et al., 2008; Gella et al., 2013). Mohammadi and Rajaie (2009) also reported the decreased in germination rate with increases allelochemicals. Reduction in seed germination under allelochemical could be due to the reduction or delay in reserve mobilization under allelopathy stress conditions (Gniazowska and Bagatek, 2005).

**Root and shoot lengths**

The root, stem, and leaf aqueous extracts of *G. abyssinica* significantly affect root length of *Parthenium* seedlings. The maximum seedlings root length was observed on leaf and stem extracts, while the minimum *Parthenium* seedlings root length (1.25cm) on the root extracts (Table-1). There is no significant difference (p<0.05) on the inhibitory effect of *G. abyssinica* plant parts (root, stem and leaf) aqueous extracts on shoot length of *Parthenium* (Table-1).

Aqueous extracts of all the three plant parts exhibited phytotoxic activity against seedling growth of the noxious weed. The susceptibility of *Parthenium* to different levels of extracts could be due to inherent differences in various biochemicals involved in the process. Gholami et al., (2011) found that allelochemicals inhibits plant root growth through generation of reactive oxygen species induced oxidative damage. These observations showed that *G. abyssinica* root may possess higher inhibitory effect on the root growth of *Parthenium* because root is the first plant part that contact allelochemicals from the solution.

Aqueous extracts of *G. abyssinica* concentration significantly affect shoot length growth. The concentration of extract part increases the inhibition of the shoot length (Table 2). The maximum (0.23cm) and minimum (5.09cm) inhibitory effect of *G. abyssinica* in shoot length was observed on 75 and 15%, respectively. The reduction in seedlings roots and shoot lengths (Table 2) may be attributed to the reduced rate of cell division and cell elongation due to the presence of allelochemicals in the aqueous extracts (Gholami et al., 2011). Jefferson and Pennacchio, (2003) concluded that reducing of seedling growth of weeds by allelochemicals in soil are detrimental to their survival since plants that usually germinate at slower rates are smaller.

### Table 1. Effect of Niger (G. abyssinica L) plant part on germination and growth of *Parthenium hysterophorus*

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Germination (%)</th>
<th>Germination rate</th>
<th>Root Length(cm)</th>
<th>Shoot Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf</td>
<td>62.22a</td>
<td>0.666b</td>
<td>1.733a</td>
<td>2.908a</td>
</tr>
<tr>
<td>Stem</td>
<td>51.67b</td>
<td>0.622a</td>
<td>1.552a</td>
<td>3.258a</td>
</tr>
<tr>
<td>Root</td>
<td>59.44ab</td>
<td>0.706a</td>
<td>1.258b</td>
<td>2.548a</td>
</tr>
<tr>
<td>SE(m)</td>
<td>14.69</td>
<td>0.15</td>
<td>0.20</td>
<td>0.28</td>
</tr>
<tr>
<td>CV(%)</td>
<td>25.42</td>
<td>8.4</td>
<td>9.92</td>
<td>11.35</td>
</tr>
</tbody>
</table>

N.B Similar letter in each column show non–significant difference according to Duncan’s Multiple Range Test (DMRT) at 0.05 level of probability.

### Table 2. Effect of different aqueous extract concentration of Niger plant on germination and growth of *P. hysterophorus*

<table>
<thead>
<tr>
<th>Aqua’s extract (%)</th>
<th>Germination (%)</th>
<th>Germination rate</th>
<th>Root Lengths (cm)</th>
<th>Shoot Lengths (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>81.11a</td>
<td>1.143b</td>
<td>3.36e</td>
<td>6.47e</td>
</tr>
<tr>
<td>15</td>
<td>77.78bc</td>
<td>0.821b</td>
<td>2.81b</td>
<td>5.09b</td>
</tr>
<tr>
<td>30</td>
<td>65.56b</td>
<td>0.739b</td>
<td>2.04c</td>
<td>3.33c</td>
</tr>
<tr>
<td>45</td>
<td>71.11bc</td>
<td>0.724b</td>
<td>0.48d</td>
<td>1.49d</td>
</tr>
<tr>
<td>60</td>
<td>41.11c</td>
<td>0.438bc</td>
<td>0.33de</td>
<td>0.81e</td>
</tr>
<tr>
<td>75</td>
<td>10.00d</td>
<td>0.121f</td>
<td>0.07e</td>
<td>0.23f</td>
</tr>
<tr>
<td>SE(m)</td>
<td>14.69</td>
<td>0.15</td>
<td>0.20</td>
<td>0.28</td>
</tr>
<tr>
<td>CV (%)</td>
<td>25.42</td>
<td>8.4</td>
<td>9.92</td>
<td>11.35</td>
</tr>
</tbody>
</table>

N.B. Similar letter in each column show non–significant difference according to Duncan’s Multiple Range Test (DMRT) at 0.05 level of probability.
was significantly affected by extracts of plant parts (leaf, stem and root). Root extract was comparatively inhibitorier than stem and leaf extracts. The maximum (0.03g) and minimum (0.016g) shoot fresh weight was recorded in leaf and root, respectively (Table-3). Aqua’s extract of G. abyssinica totally inhibited the root fresh weight of P. hysterophorus beyond 45% (Table-4) because the root is first organ of plant deals with allelopathic materials and toxin compounds. The result was also related with other reports; that reduction in growth and survival of plant may be due to inhibition of mitosis in plant (Mohamadi and Rajaie, 2009), alteration of balance in phytohormones (Chou, 1980), changes in permeability of membranes (Gniazowska and Bagatek, 2005), and stimulation or inhibition of respiration (Batish et al., 2001) under allelopathy stress could be the effective parameters. As aqueous concentration of Niger plant increased ≥15% shoot fresh weight decreased significantly (Ps0.05) (Table-4). This could be due to inhibition of protein synthesis and inhibition or alteration of the function of enzymes in the plant (Bertin et al., 2007).

### Root and shoot dry weights

The root dry weight accumulation of P. hysterophorus was equally affected by all plant parts (leaf, stem and root) (Table-3). Shoot dry weight of Parthenium weed was significantly affected by plant parts of G. abyssinica. The root and stem of G. abyssinica showed maximum inhibitory effect in shoot dry weight than the leaf (Table-3). The ANOVA result showed that shoot dry weight of Parthenium weed seedling was significantly affected with aqueous extracts of G. abyssinica (Table 4). As the concentration increases from 15 to 30% inhibitory effect increased significantly. Increase in G. abyssinica concentration beyond 15% caused total failure of shoot development. Yarnia et al., (2009) also reported that 5 to 20% leaf extract of sorghum reduced plant height, leaf area, shoot and root dry weights of Amaranths retroflexus. Besides, Dadkhah (2012) reported that application of Ephedra major aquatic extracts (15 to 45%) decreased leaf area, plant height, shoot and root weights, and chlorophyll content of Cirsium arvense and the reduction was concentration-specific. In addition, aqueous extract concentration of G. abyssinica reduced root dry weight accumulation in P. hysterophorus seedling. A significant reduction was observed with increase in aqua’s extract of G. abyssinica beyond 30% which caused complete failure of germination, thus no dry matter production (Table-4).

### CONCLUSION AND RECOMMENDATION

Niger plants poses threat on seed germination percentage and rate, seedlings root, and shoot lengths of P. hysterophorus. Aqua’s extracts of G. abyssinica inhibited Parthenium weed germination and seedlings growth and plant biomass. Germination, shoot and root lengths, fresh and dry weights of P. hysterophorus plant were adversely affected by aqueous extracts ≥15% concentration, and all plant parts have
unequal effect on the *Parthenium* weed. Aqueous extracts concentrations ≥ 60% are more effective for the management of *Parthenium*. Thus, *Guizotia abyssinica* has a great potential to be used as bio-herbicide in *Parthenium* weed control. However, verification of this study under field conditions, and identification of the allelochemicals in *G. abyssinica* should be done in the future work.

**REFERENCE**


