

# Allelopathic Effect of Aqueous Extracts of *Parthenium (Parthenium Hysterophorus L.)* Parts on Seed Germination and Seedling Growth of Maize (*Zea Mays L.*)

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## Abstract

Twice repeated experiment was carried out under laboratory conditions to investigate the allelopathic effects of aqueous extracts of *Parthenium hysterophorus* L. shoot (stem + branch) and leaf, at 0, 5, 10 and 15 g L<sup>-1</sup> (w/v) concentrations on maize (*Zea mays L.*) seed germination, seedling growth (shoot and root length) and biomass production. The treatments were laid out in completely randomized design with the factorial arrangement in four replications. Result indicated that the highest germination percentage (98.75%) was recorded from control whereas the lowest (43.75 %) was from stem extract at 15 g L<sup>-1</sup> concentration level. Similar trend was also observed by leaf extract. Root and shoot length of maize crop was reduced by 91.4 % and 70.8% by 85.6 and 35.8% leaf extracts and stem extracts respectively hence the roots were more sensitive to allelopathic effect than shoot. Extract of both leaf and stem at 15 g L<sup>-1</sup> strongly reduced fresh and dry biomass of the maize seedling. The highest (100,100 %) tolerance index was recorded from control whereas, the lowest (8.62, 14.74%) was recorded from leaf and stem extract at 15 g L<sup>-1</sup> concentration level respectively. Leaf aqueous extract showed more phytotoxic effect (91.37 %) than stem extracts (85.25) at 15 g L<sup>-1</sup> whereas was the minimum recorded in control (0.0%). 15 g L<sup>-1</sup> minimum value of vigor index (200, 539.2) and higher inhibition potentials (62.5 and 55.78%) were recorded from leaf and stem respectively. therefore allelopathic effect by the parthenium extracts is concentration-dependent manner. Leaf extract had shown highest inhibition potential followed by the stem.

**Keywords:** Allelochemicals; Parthenium; Seed germination and seedling growth; Maize.



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## 1. Introduction

Maize (*Zea mays L.*) is one of the most important crops grown throughout the world both in rainfed and irrigated areas. It is used as food, fodder and also utilized as a raw material in industries [1]. Maize and sorghum are among the main food crops cultivated in Ethiopia covering 15 and 14% of the crop lands with an average yield of 2.2 and 1.2 t ha<sup>-1</sup>, respectively. Despite the significant contribution of the crops to the livelihood of people, the crops are seriously threatened by weeds (parthenium) [2].

Parthenium is an annual herbaceous prolific weed belonging to Asteraceae family which native subtropical species of North and South America, is spreading rapidly in many parts of the world. It occurs widely along the roadsides, on wastelands and sometimes invades field crops [3]. *Parthenium hysterophorus* L., The widespread occurrence of this weed may be attributed to its aggressive behavior, very high seed production potential and suppressive effects on neighboring plants through allelopathic interactions [4].

Allelopathy concerns the effects of one plant on another due to a chemical released by them or the breakdown of their metabolites. It is expected to be an important mechanism in the plant invasion process because the lack of co-evolved tolerance of resident vegetation to a new chemical produced by the invader could allow these newly arrived species to dominant natural plant communities [5]. Reduction in native plant biodiversity in natural and agroecosystems caused by alien invasive weeds are now being recognized as some of the world's major emerging problems. *P. hysterophorus* inhibit the seed germination and seedling growth of many crops e.g. barley (*Hordeum vulgare* L.) and maize [6]. The literature on the effect of parthenium weed or its extracts on the growth of maize is quite scanty in Ethiopia. It is, therefore, imperative to study the allelopathic effect of this weed on germination and seedling growth of crops. The objective of this study is, therefore, to investigate the allelopathic effects of aqueous extracts of the shoot, and leave of Parthenium on seed germination and seedling growth of maize cultivars under laboratory conditions.

## 2. Material and Methods

### 2.1. Description of the Experimental Site

Twice repeat laboratory experiments will be conducted during winter season in February 2009 in the Plant Science Laboratory at Ambo University Gudar Campus College of Agriculture and Veterinary Science to study the allelopathic effects of Parthenium stem and leaf aqueous extracts upon the seed germination and seedling growth of maize.

## 2.2. Preparation of Aqueous Extracts of Parthenium and Its Application

*P. hysterophorus* growing naturally along the roadside of Guder town, southwestern Ethiopia, will be collected at vegetative stage and brought into the plant science Laboratory of Ambo University Guder campus, Ethiopia, and thoroughly washed with distilled water to remove inert particles. The plants will be dried with blotting paper and immediately will be separated into shoot (stem + branch) and leaf.

Each part of the fresh plant will be cut into 1 - 2 cm pieces and dried in an oven at 70 °C for 24 hours and pounded separately using stainless steel mill. 5, 10 and 15 g powder of each plant part will be weighted using sensitive balance and soaked in 100 ml of distilled water for 24 hours at room temperature (21 - 22 °C) to release allelochemicals contents in the solution. The mixture containing 5, 10 and 15 g Parthenium extracts will be collected by sieving through cheesecloth and designated as 5, 10 and 15% (w/v) aqueous extracts, respectively.

As per the ISTA standard, appropriately sized, healthy Maize seeds will be surface sterilized using 2% sodium hypochlorite for 2 to 3 min then the seeds will be washed thoroughly with sterile distilled water to remove excess of sterilant. Ten uniform sized seeds crop will be separately placed in a Petri dish (9 cm diameter) lined with 9 cm Whatman filter paper evenly. The Petri dishes will be previously surface sterilized with 70% alcohol. After placing seeds 10 mL of 5, 10 and 15% different concentrations of each shoot, and leaf aqueous extract of parthenium will be poured for each Petri dishes and 10 ml of distilled water as a control. The Petri dishes will be incubated in dark for four days. From 5th day onwards, the germinated seedlings will be exposed to 12 h light intensity and seedlings will be further grown up to 15 days. Petri dish will be regularly checked to keep them moistened by adding an equal amount of distilled water to each.

## 2.3. Experimental Design

The laboratory experiment comprised of 8 treatment will be laid out using a Completely Randomized Design (CRD) and each treatment replicated three times. The experiment will be repeated two times. 32 plastic made Petri dishes (9 cm diameter in size) will be randomly arranged following CRD design inside the plant science Laboratory

## 2.4. Data collection

1. Germination percentage will be calculated by using the formula prescribed by ISTA [7].

$$\% \text{ Germination} = \frac{\text{Number of seeds germinated}}{\text{Number seeds planted}} \times 100$$

2. **Root length (cm):** will be measured from root-shoot zone to the tip of the longest root by a graduated meter scale.

3. **Shoot length (cm):** will be also recorded from root-shoot zone to the tip of the topmost leaf by a graduated scale.

4. **Fresh weight:** the fresh seedlings will be weighed using electrical balance to determine the fresh weight

5. **Dry matter:** The seedlings will be dried in a hot air oven at 80 °C for 48 h and then dry weight will be estimated in an electrical balance.

6. **Vigor Index:** Vigour index of the seedling was calculated by using the formula suggested by Abdul-Baki and Anderson [8] as follows:

$$VI = (\text{Mean root length} + \text{Mean shoot length}) \times \text{Germination percentage}$$

7. **Tolerance index:** Tolerance index will be calculated by using the formula suggested by Turner and Marshal (1972) as follows:  $TI = \frac{\text{Logest root length in treatment}}{\text{longest root length in control}} \times 100$

8. **Percentage of toxicity:** will be calculated by the formula suggested by Chiou and Muller [9].

$$\text{Phytotoxicity (\%)} = \frac{\text{Radical length of control} - \text{Radical length of treated}}{\text{Radical length of control}} \times 100$$

9. **Inhibition percentage:** will be calculated as percent inhibition of germination over control treatment (distilled water).  $\text{Inhibition (\%)} = \frac{\text{Germination in treated} - \text{Germination in control}}{\text{Germination in control}} \times 100$

## 2.5. Data Analysis

Finally, the average data obtained from the two experiments will be subjected to analysis of variance using scientific calculator manually. The treatment means were compared with least significant difference (LSD) tests at the 5% significance level.

# 3. Results and Discussion

## 3.1. Germination Percentage

Aqueous extracts of stem and leaf plant parts of Parthenium exhibited allelopathic effects on maize. The effect of stem part of the parthenium extract on crop showed that the concentration affected the germination percentage of the crop. As the data in Table (1) indicated that the highest germination percentage (98.75%) was recorded from control whereas the lowest (43.75 %) was from 15 g L<sup>-1</sup>. Similarly, the extract of leaf part was also significantly

affected the germination percentage of the maize crop. The highest germination percentage (100 %) was recorded from control whereas the lowest (37.5 %) was from 15 g L<sup>-1</sup>. The effect of leaf extract was higher as compared to stem extract (Table 1). A similar result was also reported by Anteneh [2] stated the allelopathic effect varied among plant parts from which the aqueous extracts were taken [10, 11] that high level of inhibitory compounds present in these parts of the plant as compared to stems. Interestingly as the concentration of the extract increased, the germination percentage was decreased. This may be due the allelochemicals present in the leaf extract prevented the embryo development and embryo growth and caused death. The extract of *Parthenium hysterophorus* induced a variety of chromosomal aberrations in dividing cells, which increased significantly with increasing concentrations and durations of exposure. These results are in accordance with the work of Devi and Dutta [12] who stated that extract of *Parthenium hysterophorus* and treated seeds of *Zea Mays* (L), germination was less in all the concentrations used as compared to control.

### 3.2. Shoot Length

Different concentrations of *Parthenium* had significant effects on shoot length of the crop. As the data showed in the Table (1) indicated that shortest (4.10 cm) 15 g L<sup>-1</sup> whereas the longest (14.06 cm) was observed from the control which was not statistically significant from 5 g L<sup>-1</sup>. The similar trend observed in stem extract. The difference in the activity of aqueous parthenium extracts prepared from different fractions in suppressing germination of test species can be attributed to quantitative and qualitative differences in allelochemicals present in these extracts (Table 1, and Fig 1a). More inhibition by application of higher extract concentration may be due to the presence of a greater fraction of allelochemicals in concentrated extracts [13].

### 3.3. Root length

Significant suppression in root length of was forced by different extract sources at higher concentrations. The root length of the crop decreased by an increase in the concentration of *Parthenium* (Table 1, and Fig 1b). Root length of maize crop was reduced by 80% and 71% by whole plant extracts, 94.1 % and 85.5% by leaf extracts and stem extracts, respectively. It may be due to the presence of more phenolic contents in leaf than stem extracts. Similarly, Phytotoxicity of foliar parts of parthenium weed is well documented [14, 15].

### 3.4. Fresh Biomass

Analysis of the data showed the significant inhibitory effect of the stem and leaf extracts upon the fresh biomass of the four wheat cultivars. ( $p < 0.01$ ; Table 1) The leaf extract of the weed had shown the highest inhibition as compared to stem extract and the crop had produced the lowest fresh biomass per plant (7.08, 7.08 g) in case of whereas the minimum fresh biomass (0.93, 2.23 g/ plant) was recorded from the stem and leaf extract at 15 g L<sup>-1</sup> respectively. [16, 17] have also presented similar findings. They recorded significant reduction in the biomass of wheat and other cereal crops seedlings when treated with the vegetative parts of parthenium. This growth inhibitory effect of the weed extracts upon the seedlings growth of wheat may have had occurred due to the presence of parthenin in *Parthenium* plant.

### 3.5. Dry Biomass

The effect of extracts from different parts of parthenium weed on dry biomass of maize was found statistically significant. Irrespective of the source of the extracts, the total dry biomass of the test crop was significantly ( $p < 0.01$ ) affected by the weed extracts (Table 1). The leaf extract of the weed had shown the highest inhibition as compared to stem extract and the crop had produced the lowest fresh biomass per plant (2.45, 1.71 g) in case of whereas the minimum dry biomass (0.25, 0.15 g/ plant) was recorded from the leaf and stem extract at 15 g L<sup>-1</sup> respectively. From Fig 1c and Table 1 it was observed that the percentage of the total dry weight of maize seedling was gradually increased with the gradually decrease in due to the less allelopathic effect of parthenium weed. Therefore, the weed had a strong inhibitory effect on the total dry weight of maize.

### 3.6. Tolerance Index

Effect of different level of extract from different part of parthenium significantly affected the tolerance index of maize seedling. The highest (100,100 %) tolerance index was recorded from control whereas, the lowest (8.62, 14.74%) was recorded from leaf and stem extract at 15 g L<sup>-1</sup> concentration level (Table 1). As the concentration level of both parts increased the tolerance index was decreased (Table 1 and Fig 2a). These finding are in agreement with work of Tahseen, *et al.* [18] Tolerance index significantly reduced with increasing parthenium concentration when compared to control.

### 3.7. Phytotoxicity

Phytotoxicity in maize seedlings at different concentration of aqueous extracts was found to be significantly different (Table 1). Phytotoxicity increased with increase in the concentration of aqueous extracts (Table 1, and Fig 2b). Leaf aqueous extract showed more phytotoxic effect (91.37 %) than stem extracts (85.25) at 15 g L<sup>-1</sup> respectively whereas was recorded in control (0.0%) (Table 1). These results are in agreement with work of Tahseen, *et al.* [18] who found strong relation between increased aqueous extract concentrations of *Parthenium hysterophorus* and increased toxicity to some agronomic crops and weed plants.

**Table-1.** Effect of different concentration of aqueous extracts of Parthenium plant parts on maize seed germination, and seedling growth and biomass production, tolerance index, phytotoxicity and vigour index

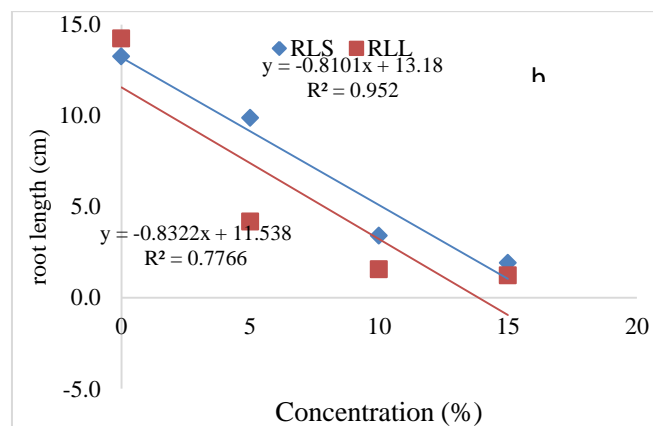
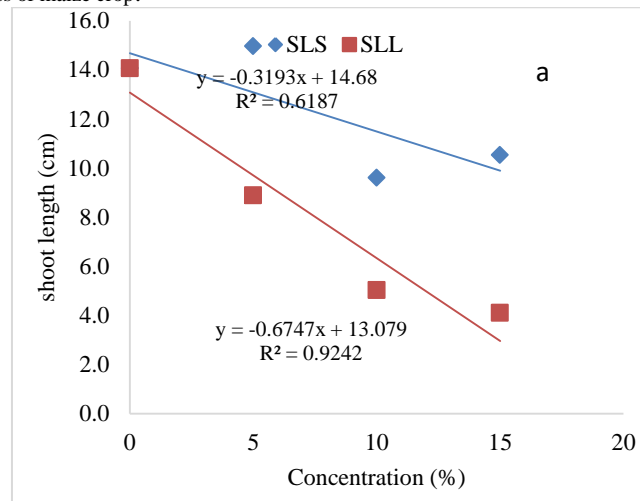
Plant part	Concentration Level (g L <sup>-1</sup> )	Germination percentage (%)	Shoot length(cm)	Root length (cm)	Fresh weight (g)	Dry weight (g)	Tolerance Index (%)	Phytotoxicity (%)	Vigour index
Stem	0	98.75a	14.95a	13.24a	7.08a	2.45a	100.0a	0.00c	2705.9a
	5	62.5b	14.06a	9.873a	4.88b	0.51ab	76.96b	23.03b	1548.7b
	10	52.5bc	10.52b	3.40b	2.55c	0.29b	28.29c	71.70a	705.4c
	15	43.75c	9.60b	1.90	2.23c	0.25b	14.74	85.25a	539.2c
	LSD	13.9	2.5	3.66	1.73	2.15	14.76	14.76	531.38
	CV	4.09	3.27	3.45	6.95	8.9	7.42	4.30	5.08
Leaf	0	100a	14.06a	14.22a	7.08a	1.71a	100.0a	0.00c	2828.4a
	5	50.0b	8.88b	4.17b	2.73b	0.34b	10.78b	69.75b	631.9b
	10	40.0b	5.02c	1.55c	1.13c	0.16b	10.78b	89.21a	262.9bc
	15	37.5b	4.10c	1.22c	0.93c	0.15b	8.62b	91.37a	200.9c
	LSD	14.23	1.97	2.55	1.53	1.0	4.21	8.66	395.64
	CV	6.24	5.95	3.35	3.51	9.7	8.40	8.98	6.17

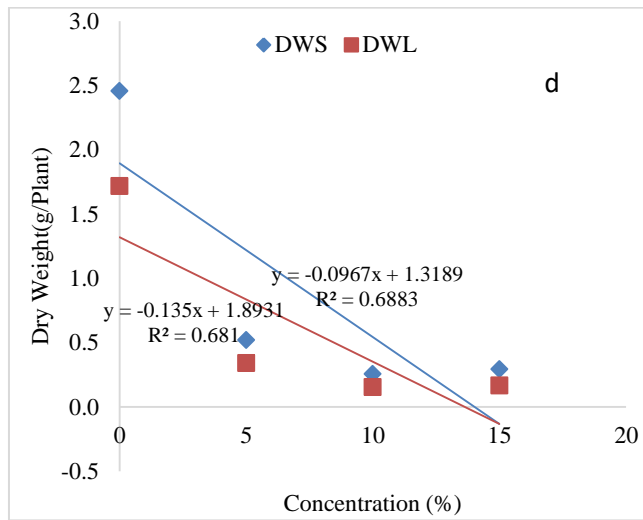
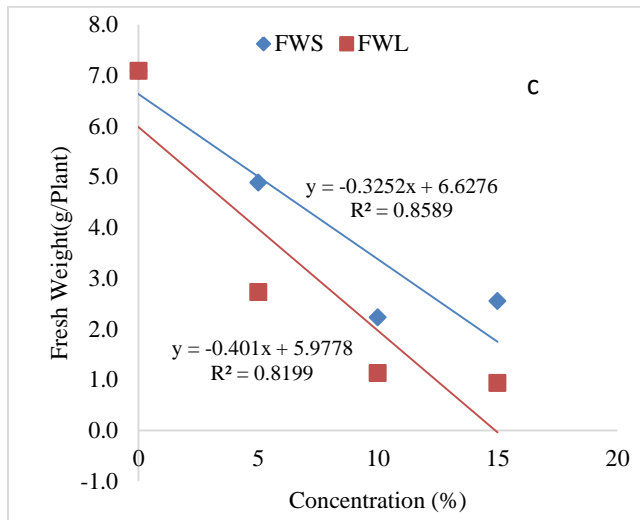
Means with the same letters are not significantly different at P=0.05 LSD: Least Significant Difference; CV: Coefficient of Variation

### 3.7. Vigor Index

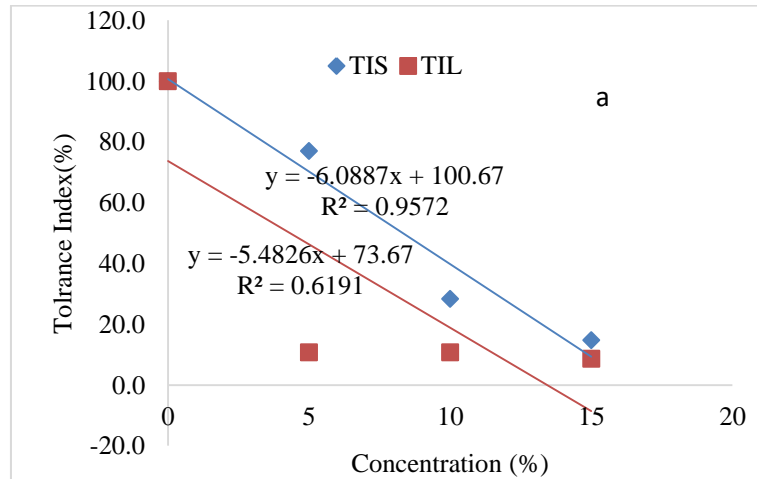
Vigour index significantly decreased when to compare with control (Table 1). The maximum and minimum value of vigour index were recorded in control sets (2705.9) and 15 g L<sup>-1</sup> aqueous extract of stem (539.2), respectively. In leaf, the maximum vigour index (631.9) was recorded at 5 g L<sup>-1</sup> and minimum value of were recorded (200) at 15 g L<sup>-1</sup>. As the concentration of extracts increased the vigour index was decreased (Table 1 and Fig 2c)

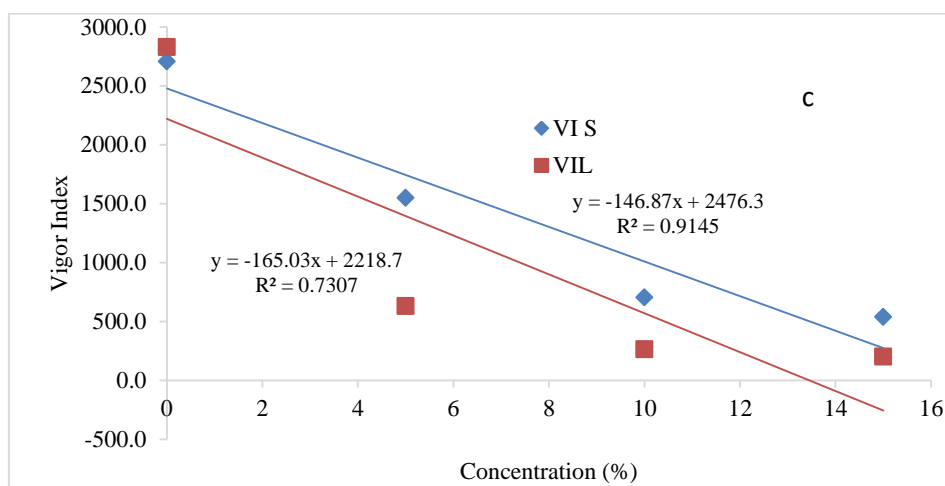
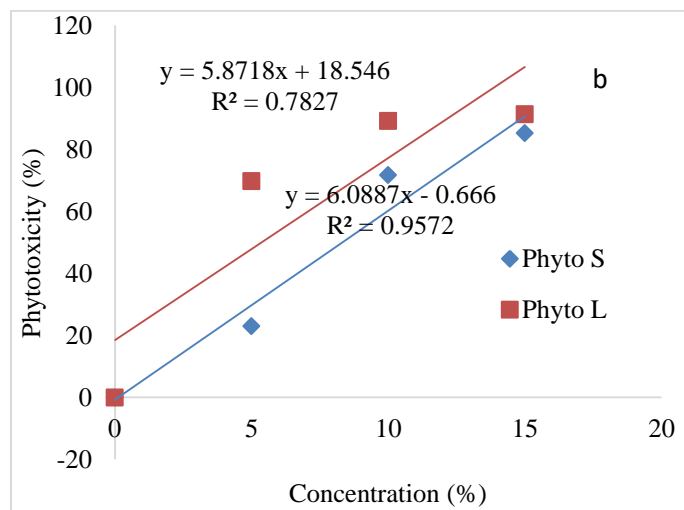
**Figure-1.** The relationship between concentrations of leaf and stem aqueous extract of Parthenium hysterophorus on a shoot (a) and root (b) length, fresh(c) and dry (d) biomass of maize crop.





**Figure-2.** Relationship between concentration of leaf and stem aqueous extract of Parthenium and Tolerance index (a), phyto-toxicity percentage (b) and vigor index(c)

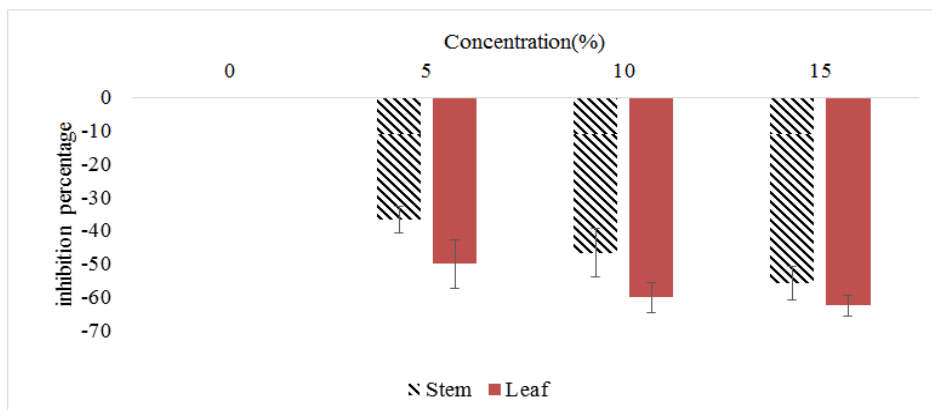




### 3.8. Inhibition Percentage

It reveals that the inhibition potentials of the leaf, and stem root extracts at their 15 g L<sup>-1</sup> concentrations were 62.5 and 55.78% for maize seed germination over control respectively. The lowest inhibition in seed germination of about 36.57 and 50% over control was found for the extracts at 5 g L<sup>-1</sup> concentration from stem and leaf respectively and as the dose increased the inhibition was also increased (Fig. 3). Therefore, the weed extract had a strong inhibitory effect on seed germination of maize. The ranking of the parthenium weed aqueous extract from different parts in respect of inhibitory effect on seed germination was in the order leaf>stem. The similar results were found by Ahmed, *et al.* [19]. They applied leaf extracts of Siam (*C. odorata*) on receptor crops and observed that the inhibitory effect was proportional to the concentrations of the extracts and higher concentration had the stronger inhibitory effect.

**Figure-3.** Inhibition potential of the aqueous extracts from parthenium weed on maize seed. Vertical bars represents the standard error at 5% level of significance



### 4. Conclusion

From this laboratory experiment reveal that in the control treatment (distilled water) had maximum germination percentage and 15 g L<sup>-1</sup> concentration had the minimum. Different concentrations of the aqueous extracts from the



parthenium significantly inhibited the seedling growth of maize and the inhibition varied with the concentration of the extracts. Germination was maximum (around 100%) in the crop in control (distilled water), whereas was reduced to as low as 37.5% in case of leaf extract at 15 g L<sup>-1</sup>. Extract of both leaf and stem at 15 g L<sup>-1</sup> strongly reduced the root length, shoot length, fresh and dry biomass of the maize seedling. Results also show that 15% extract had the highest inhibitory percentage, while lower tolerance index and vigor index. Allelopathic effect by the parthenium extracts in a concentration-dependent manner but shoot growth was less susceptible than the root. Leaf extract had shown highest inhibition potential followed by the stem. Thus, the inhibition order was as follows leaf extract greater than stem extract.

## Acknowledgement

The author thanks to Ambo University for their financial support to conduct this study and mister Fulea Gelana for his dedicated supportive during conducting the experiment.

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