Advances in Crop Science and Technology

Sorecha and Bayissa, Adv Crop Sci Tech 2017, 5:3
DOI: 10.4172/2329-8863.1000285

Research Article OMICS International

Allelopathic Effect of *Parthenium hysterophorus* L. on Germination and Growth of Peanut and Soybean in Ethiopia

Eba Muluneh Sorecha* and Birhanu Bayissa
School of Natural Resources Management and Environmental Sciences, Haramaya University, Dire Dawa, Ethiopia

Abstract

The present study was conducted to investigate the allelopathic effects of *Parthenium hysterophorus* weed on seed germination and early growth stages of peanut and soybean. Leaf, stem, and root aqueous extracts of Parthenium at 0, 2, 4, 6, 8, and 10 g/1000 ml concentrations were applied to determine their effect on both crops seed germination and early growth stages under laboratory conditions. Two runs of laboratory-based experiment with factorial Complete Randomized Design (CRD) with three replications was used to arrange treatments accordingly. The result of study revealed that peanut seed germination only significantly ($P \leq 0.05$) responded to the parthenium stem and root extracts; where on average 2 and 4 seeds were germinated per petridishes, respectively under high concentration treatment of 10 g/1000 ml. whereas, soybean seed germination was significantly responded to all the parthenium plant parts extracts. However, the serious effects have been well observed under the treatments of 10 g/1000 ml stem extracts and 8 g/1000 ml root extracts, where no germination of soybean seed was recorded. Similarly, shoot length was seriously inhibited by the stem extracts for peanut and leaf extracts for soybean, accounting 5.67 and 1 cm, respectively. However, the least average root length of 3.33 cm for peanut and 0.67 cm for soybean has been noticed with the leaf aqueous extracts under 10 g/1000 ml. The study also revealed that the phytotoxicity of parthenium plant parts increase with the increasing concentrations of extracts. Phytotoxicity of parthenium has been more pronounced over soybean germination and early growth stages than peanut.

Keywords: Allelopathic; Germination; *Parthenium hysterophorus*; Shoots and root length

Introduction

Weeds are the most costly category of agricultural pests, causing great yield loss and labor expense. Agricultural weeds can emerge rapidly, resulting in reduction of crop plant growth and quality by competing for nutrients and water provided to crops and producing chemicals that suppress crop growth. *Parthenium hysterophorus* is one of the best known plant invaders in the world linking allelopathy to exotic invasion. The antagonism between weeds and crops in the field of agriculture is a complex interaction which could be allelopathic effect, physical competition, or both. Allelopathy is an interference mechanism in which live or dead plant materials release chemical substances, either inhibit or stimulate the associated plant growth [1]. Several studies [2-5] have been indicating that a number of weeds have an allellophatic effects on seed germination and growth of economically important crops.

The study of allelopathy is a difficult, as there is a difficulty in separating those of competition, because growth and yield may be influenced by each [6]. For example, adverse effect of plant residues on seed germination and plant growth could be the result of immobilization of large amounts of nutrients by micro-organisms involved in decomposition, by allelochemicals, or both [7]. Aqueous extracts of Parthenium leaf and flower inhibited seed germination and caused complete failure of seed germination of crops when the leaf extract concentration of Parthenium weed was increased. Again, yield decline in agricultural crops and reduction in forage production has been reported due to allelopathic effect of Parthenium.

Among those weeds *Parthenium hystherophorus* is a major one posing greater challenges to the economic, food security and sustainable development of many developing countries whose livelihood is of totally or partially depend on agriculture [8-10]. *Parthenium hysterophorus* L., a noxious weed, occurring widely in tropics and sub-tropics, is a major problem in Ethiopia [11], India and Australia [12]. Allelopathic activity of different parts of this cosmopolitan weed has been well documented [13-16]. Discharge of allelochemicals into the environment occurs by exudation of volatile chemicals from living plant parts, by leaching of water soluble toxins from aboveground parts in response of action of rain, by exudation of water soluble toxins from below ground parts, by release of toxins from non-living plant parts through leaching of litter decomposition.

In Ethiopia despite some stray observations, there are no such sufficient scientific evidences on the extent that allelopathic effect of weeds on growth and productivity of economically important crops like peanut and soybean. Therefore, this study was made to investigate the effects of allelopatic chemicals of *Parthenium hysterophorus* plant part (leaf, Stem, root) aqueous extracts on germination and early growth stages of peanut and soybean crops under a laboratory condition.

Materials and Methods

Test place

Two runs of laboratory-based experiment were conducted under room temperature in Environmental Science Program Laboratory, Haramaya University during February and March, 2017. A factorial Complete Randomized Design (CRD) with three replications was used to arrange treatments accordingly. The experiment has: Factor A: Two crops variety: Peanut and soybean; Factor B: Extracts of the three main plant parts: leaf, stem and root parts, and distilled water as control treatment. Five treatments, solution of parthenium extracted aqueous

***Corresponding author:** Eba Muluneh Sorecha, School of Natural Resources Management and Environmental Sciences, Haramaya University, PO Box 138, Dire Dawa, Ethiopia, Tel: +251946428388; E-mail: ebamule1@gmail.com

Received May 09, 2017; **Accepted** May 17, 2017, 2017; **Published** May 24, 2017

Citation: Sorecha EM, Bayissa B (2017) Allelopathic Effect of *Parthenium hysterophorus* L. on Germination and Growth of Peanut and Soybean in Ethiopia. Adv Crop Sci Tech 5: 285. doi: 10.4172/2329-8863.1000285

(2,4,6,8, and 10 g/1000 ml) and the control, distilled water were prepared and used for the experiment.

Plant material

A vegetative growing fresh tissue of the parthenium weed was collected from fields in Haramaya University. The collected weed (parthenium) was separated into leaf, stem and root parts, then crushed to the size of <2 mm and grinded, with grinding machine particularly used for this purpose. The grinded plant material was mixed in distilled water at 1 g/ml ratio, soaked and blended with blender as of [17,18] for 24 hours. Then after, the mixtures were extracted by using 100 × 100 rpm centrifuge for twenty minutes. The filtered aqueous extracts were poured into long necked and flat bottomed 250 ml volumetric flasks, well covered and preserved in refrigerator set to -5°C for use in a test experiment. Seven healthy, pure-line, viable [tested following ISTA [19] rules] seeds of both crops were procured from Haramaya University, Oil and Pulse Crop Research Team, Ethiopia. Both seeds were sown sparsely in a filter paper covered glass petri dish having 9.5 cm diameter. A 5 ml aqueous extract of parthenium were applied to each petridishes; on the other hand, 5 ml distilled water were applied in the case of control treatment. The treated petridishes were placed at room temperature. Moistening seeds with equal amount of water and germination and early growth stages data for both crops were collected on daily basis after planting.

The formula used to calculate germination percentage and phytotoxicity is indicated hereafter:

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

$$Phytotoxicity = \frac{Radicle\ length\ of\ control - radicle\ length\ of\ treated\ sample}{Radicle\ length\ of\ control} \times 100$$

Data analysis

The collected data were subjected to analysis of variance procedure with SAS Version 9.1 and the means were compared by using LSD at the 5% level of probability.

Results and Discussion

Germination test

Seed germination of peanut was not significantly (P ≤ 0.05) responded to the parthenium aqueous leaf extracts. However, it significantly responded to the parthenium aqueous stem extracts. Of the 7 seeds sown, only 2 seeds were germinated under high concentration treatment of (10 g/1000 ml) of stem extracts. Under the rest of the treatments (0, 2, 4, 6 and 8 g/1000 ml), germination of the peanut seed were not statistically different (Table 1). Moreover, germination of peanut seed was responded significantly to the aqueous extracts of root having the lowest germinated seed of about 4 per petridishes. Whereas, the highest mean values of seed germination were noticed under 8 g/1000 ml and control about 6 seeds for both treatments (Table 2). Rajendiran [20] reported that allelochemicals present in the parthenium plant parts could prevent the embryonic 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.

The study also revealed that increase in the concentration of parthenium plant extracts confidentially inhibits the germination of peanut seeds under laboratory condition. Comparing the parthenium plant aqueous extracts, it was stem extract that highly reduce the germination of peanut seeds accounting about 28.57% under high concentration treatment, 10 g/1000 ml, followed by leaf extracts in which about 71.43% seeds were germinated under 8 and 10 g/1000 ml (Table 3).

Treatments (g)	Leaf	Stem	Root
0 Control	6.00^{a}	6.00^{a}	6.00^{a}
2	6.00^{a}	6.00^{a}	5.33^{ab}
4	5.67^{a}	5.67^{a}	6.00^{a}
6	6.00^{a}	5.33^{a}	5.67^{ab}
8	5.00^{a}	5.67^{a}	6.00^{a}
10	5.00^{a}	2.00^{b}	4.67^{b}
CV%	**15.15**	**11.30**	**10.29**
LSD	**1.512**	**1.027**	**1.027**

Note: means with the same letter in the same column are not statistically significant different at p<0.05 level according to LSD test.

Table 1: Mean comparison for germination of peanut seed influenced by leaf, stem and root extracts per petridishes.

Plant parts	0 Control	2%	4%	6%	8%	10%
Leaf	85.71	85.71	80.95	85.71	71.43	71.43
Stem	85.71	85.71	80.95	76.19	80.95	28.57
Root	85.71	76.19	85.71	80.95	85.71	76.67

Table 2: Effects of parthenium plant parts extract on the germination of peanut.

Germination of soybean seed was significantly responded to all the parthenium plant parts extracts considered in this study. Compared to the control treatment, the least mean value of germinated seeds were recognized under high concentration treatments of 10 g/1000 ml of leaf extracts, about 0.33, followed by 6 g/1000 ml treatment about 1.33, though not statistically significantly different. However, it has been well notified that under 10 g/1000 ml of stem extracts and under 8 g/1000 ml of root extracts, there was no germination of soybean. This might be due to the allelophatic effects of parthenium weeds on the seeds of soybean. According to Tefera [21] aqueous extracts of parthenium leaf and flower inhibited seed germination and caused complete failure of seed germination of teff (*Eragrostis teff*) under high concentration of parthenium exactas 10%.

The higher the concentration of parthenium plant extracts, the higher the influences on the germination of soybean under laboratory condition. Under 2 and 4 g/1000 ml treatments, leaf aqueous extracts had higher germination inhibition than stem and root extracts. Whereas, under 6 g/1000 ml treatment, stem aqueous extract showed the highest germination of soybean seed, about 52.38 compared with leaf and root extracts (Table 4).

Shoot length

Shoot length of peanut significantly responded to the leaf, stem and root aqueous extracts. However, the response depends on the concentrations considered for this particular study. For instance, the lowest average value of peanut shoot length was observed under 10 g/1000 ml treatment, about 6.67 cm, followed by 12.33 cm under treatment of 8 g/1000 ml. whereas, the shoot length was seriously inhibited by the stem aqueous extracts accounting 5.67 cm (Table 5). In all plant parts extracted, the increment in the concentrations inhibits the shoot length of peanut under the laboratory situation.

Similarly, it could be seen from Table 6 that the aqueous extracts of parthenium plant parts reduced the shoot length of soybean comparing with the control treatments. The intensity of shoot length reduction

Treatments (g)	Leaf	Stem	Root
0 Control	6.67^{a}	6.33^{a}	6.00^{a}
2	3.67^{b}	3.00^{bc}	2.67^{b}
4	3.33^{b}	3.00^{bc}	1.67^{bc}
6	1.33^{c}	3.67^{b}	1.00^{cd}
8	1.67^{c}	1.00^{cd}	0.00^{d}
10	0.33^{c}	0.00^{d}	0.33^{d}
CV%	**28.8**	**47.05**	**29.69**
LSD	**1.453**	**2.372**	**1.027**

Note: means with the same letter in the same column are not statistically significant different at p<0.05 level according to LSD test.

Table 3: Mean comparison for germination of soybean seed influenced by leaf, stem and root extracts per petridishes.

Plant parts	0 Control	2%	4%	6%	8%	10%
Leaf	91.43	52.38	47.62	9.52	23.81	4.76
Stem	88.57	42.86	42.86	52.38	14.29	0.00
Root	88.57	38.10	23.81	14.29	0.00	4.76

Table 4: Effects of parthenium weed extracts on the germination of soybean.

Treatments (g)	Leaf	Stem	Root
0 Control	29.67^{a}	27.67^{a}	27.67^{a}
2	27.33^{a}	25.33^{a}	26.67^{ab}
4	21.00^{b}	18.00^{b}	22.33^{b}
6	15.67^{c}	12.33^{c}	14.33^{c}
8	12.33^{c}	10.67^{c}	13.33^{c}
10	6.67^{d}	5.67^{d}	10.67^{c}
CV%	11.23	15.67	13.66
LSD	3.75	4.63	4.63

Note: means with the same letter are not statistically significant different at alpha level of 0.05.

Table 5: Mean comparison for Shoot length (cm) of peanut as influenced by parthenium plant parts aqueous extracts.

Treatments (g)	Leaf	Stem	Root
0 Control	34.33^{a}	30.67^{a}	27.00^{a}
2	27.00^{a}	27.00^{a}	29.00^{a}
4	17.00^{b}	19.00^{b}	23.00^{ab}
6	1.33^{c}	2.33^{c}	6.33^{c}
8	3.33^{c}	3.67^{c}	12.67^{bc}
10	1.00^{c}	1.33^{c}	6.33^{c}
CV%	31.54	19.63	38.43
LSD	7.856	4.89	11.89

Note: means with the same letter are not statistically significant different at alpha level of 0.05.

Table 6: Mean comparison for shoot length (cm) of soybean as influenced by parthenium plant parts aqueous extracts.

increases with the increasing concentrations of aqueous extracts. Leaf aqueous extracts significantly inhibited the shoot length of soybean than the rest two parthenium plant parts extracts (Table 6). The study indicated that the concentrations beyond 6 g/1000 ml of all plant parts (leaf, stem and root) highly influenced the length of soybean (Table 6). Similar trend was reported by Ref. [22] who indicated that increased aqueous extract concentrations of *Parthenium hysterophorus* have increased effects on the germination of crops. Earlier works [23] have also reported that those chemicals found within *Parthenium hysterophorus* inhibited root and shoot elongation of maize and soybean.

Root length

Table 7 shows the root length of peanut as influenced by the aqueous extracts of parthenium plant parts. Root length of peanut significantly responds to the leaf, stem and root aqueous extracts. The presents study also indicated that 10 g/1000 ml treatment of all plant parts considered highly influenced the root growth of peanut under the laboratory condition. The least average root length (3.33 cm) of peanut had been observed with the leaf aqueous extracts compared with stem and root extracts (Table 7).

Furthermore, the study of analysis of variance showed that the root length of soybean significantly responded to the effects of aqueous extracts of parthenium plant parts. The least average value (0.67 cm) of root length of soybean had been noticed under higher concentration of solutions prepared, which is leaf aqueous extracts followed by stem extracts, about 2.67 cm (Table 8). The effects of root aqueous extracts had showed the least impact on the root length of soybean comparing with the rest two parthenium plant parts extracts (Table 8). This might be due to higher accumulation of allelochemicals found in the other plant parts than in root parts.

Phytotoxicity

The Phytotoxicity of parthenium plant parts against the two crops selected has been investigated and indicated in Tables 9 and 10. The study shows that the phytotoxicity of parthenium plant parts increase with the increasing the concentrations of the treatments from control 0 to the highest treatment of 10 g/1000 ml (Tables 9 and 10). The Phytotoxicity of leaf has been recognized as the highest impact affecting the germination and early growth of the two crops, peanut and soybean. Comparatively, the Phytotoxicity of parthenium plant parts has been more pronounced over soybean germination and early growth stages (Table 10). Some researchers argue that, the effect of *Parthenium hysterophorus* aqueous extract is species specific like in barley, wheat and soybean [24,25].

Treatments (g)	Leaf	Stem	Root
Control	21.67^{a}	26.67^{a}	26.33^{a}
2	19.00^{ab}	19.00^{b}	22.33^{b}
4	15.67^{bc}	16.33^{bc}	21.67^{b}
6	14.67^{c}	16.33^{bc}	16.00^{c}
8	9.67^{d}	14.33^{c}	14.67^{cd}
10	3.33^{e}	6.33^{d}	11.33^{d}
CV%	16.92	10.4	11.67
LSD	4.21	3.05	3.89

Note: means with the same letter are not statistically significant different at alpha level of 0.05.

Table 7: Mean comparison for root length (cm) of peanut as influenced by parthenium plant parts aqueous extracts.

Treatments (g)	Leaf	Stem	Root
Control	21.00^{a}	26.33^{a}	27.33^{a}
2	16.67^{b}	23.67^{a}	25.33^{a}
4	9.00^{c}	16.00^{b}	21.67^{ab}
6	1.00^{d}	2.67^{c}	6.00^{c}
8	2.33^{d}	9.00^{c}	12.67^{bc}
10	0.67^{d}	2.67^{c}	6.67^{c}
CV%	25.12	26.81	47.97
LSD	3.77	6.39	12.40

Note: means with the same letter are not statistically significant different at alpha level of 0.05.

Table 8: Mean comparison for root length (cm) of soybean as influenced by parthenium plant parts aqueous extracts.

Treatments (g)	Leaf	Stem	Root
Control	0.00	0.00	0.00
2	5.00	20.83	6.94
4	12.96	34.67	13.33
6	26.67	18.33	40.74
8	46.30	20.37	51.11
10	87.65	76.54	59.52

Table 9: Mean comparison for Phytotoxicity of parthenium plant parts aqueous extracts against Peanut seed germination and early growth stages.

Treatments (g)	Leaf	Stem	Root
Control	0.00	0.00	0.00
2	16.67	1.39	2.56
4	50.00	36.00	13.33
6	95.00	90.12	77.78
8	87.04	70.00	57.78
10	97.53	90.48	76.19

Table 10: Mean comparison for Phytotoxicity of parthenium plant parts aqueous extracts against soybean seed germination and early growth stages.

Conclusion

The study attempts to investigate the allelophatic effects of parthenium plant parts, leaf, stem and root on the germination and early growth of peanut and soybean seeds. In line with this, it could generalized that germination of both seeds have been seriously inhibited with the aqueous extracts of parthenium plant parts. The severity of parthenium against seeds, peanut and soybean increases with the increasing concentration of the extracts. This implies that in areas with high infestation of this weed, growing both kinds of crops might be at risk. Therefore, further investigation how to control this weed is critical.

Acknowledgments

It's our pleasure to thanks Mr. Arbo Feyissa, Coordinator of Environmental Sciences Program for his kind response while we requested for laboratory activities. Again, we would like to extend our sincere appreciation to Dr. Lemma Wogi, Head, School of Natural Resources Management and Environmental Sciences for all facilitation required for this particular work.

References

1. May FE, Ash JE (1990) An assessment of the allelopatic potential of ecualyptus. Aust J Bot 38: 245-254.
2. Rice EL (1984) Allelopathy. 2nd edn. New York Academic Press.
3. Shibu J, Andrew RG (1998) Allelopathy in black walnut (Juglans nigra L.) alley cropping. II. Effects of juglone on hydroponically grown corn (Zea mays L.) and soybean (Glycine max L. Merr.) growth and physiology. Plant and Soil 203: 199-206.
4. Delabays Mermilled NG, De Jofferey JP, Bohre C (2004) Demonstration in a cultivated fields, of the reality of the phenomenon of allelopathy. 12th Int Conf Weed Boil, pp: 97-104.
5. Mulatu W, Gezahegn B, Solomon T (2009) Allelopathic effects of an invasive alien weed Parthenium hysterophorus L. compost on lettuce germination and growth. Afr J Agric Res 4: 1325-1330.
6. Batish DR, Singh HP, Kohli RK, Kaur S, Saxena DB, et al. (2007) Assessment of parthenin against some weeds. Zeitschrift für Naturforschung 62: 367-372.
7. Wakjira M, Berecha G, Tulu S (2009) Allelopathic effects of invasive alien weed Parthenium hysterophorus L. compost on lettuce germination and growth. African Journal of Agricultural Research 4: 1325-1330.
8. Maharjan S, Shrestha BB, Jha PK (2007) Allelopathic Effects of Aqueous Extract of Leaves of Parthenium Hysterophorous L. on Seed Germination and Seedling Growth of Some Cultivated and Wild Herbaceous Species. Scientific World 5: 33-39.
9. Mcconnachie AJ, Wstrathie L, Mersie W, Gebrehiwot L, Zewdie K, et al. (2010) Current and potential geographical distribution of the invasive plant Parthenium hysterophorus (Asteraceae) in eastern and southern Africa. Weed Research 51: 71-84.
10. Dinwiddie R (2014) Composting of an invasive weed species Parthenium hysterophorus L. An agroecological perspective in the case of Alamata woreda in Tigray, Ethiopia. Master's Thesis in Agricultural Science/Agroecology. SLU, Swedish University of Agricultural Sciences, p: 79.
11. Tamado T, Ohlander L, Milberg P (2002) Interference by the weed Parthenium hystrophorus L with grain sorghum: Influence of weed density and duration of competition. Int J Pest Manage. 48: 183-188.
12. McFadyan RE (1984) Parthenium weed. Aust Weeds 3: 2-4.
13. Mall LP, Dagar JC (1979) Effect of Parthenium hysterophorus extract on the germination and early seedling growth of three crops. J Ind Bot Soc 58: 40-43.
14. Kanchan SD (1975) Growth inhibitors from Parthenium hysterophorus Linn. Curr Sci 42: 729-730.
15. Sarma KV, Girl GS, Subrahmanyam K (1976) Allelopathic potential of Parthenium hysterophorus L. on seed germination and dry matter production in Arachis hypogaea Willd., Crotalariajuncea L. and Phaseolus mungo L. Tropical Ecology 17: 76-77.
16. Sukhada DK, Jayachandra J (1980) Allelopathic effects of Parthenium hysteorphorus L. Part II. Leaching of inhibitors from aerial vegetative parts. Plant and Soil 55: 61-66.
17. Oudhia PN, Pandey P, Thipati RS (1999) Allelopathic effects of weeds on germination and seedling vigor of hybrid rice. Department of Agronomy, Indra Gandhi Agricultural University (IGAU), Raipur, Madhya Pradish, India.
18. Marwat KB, Khan MA, Nawaz A, Amin A (2008) Parthenium hysterophorus L. - A potential source of Bioherbicide. Pak J Bot 40: 1933-1942.
19. International Seed Testing Association (1976) Standard procedures in the field of seed testing.
20. Rajendiran K (2005) Simple and rapid squash schedule for the root tips of Helianthus annuus to determine the environmental clastogens. Journal of Ecotoxicology and Environmental Monitoring 15: 291-295.
21. Tefera T (2002) Allelopathic effects of Parthenium hysterophorus L. extracts on seed germination and seedling growth of Eragrostis tef. J Agron Crop Sci 188: 306-310.
22. Mersie W, Singh M (1988) Effect of phenolic acids and ragweed Parthenium (Parthenium hysterophorus) extract on tomato (Lycopersicon esculentum) growth and nutrients and chlorophyll content. Weed Science 36: 278-281.
23. Bhatt B, Chauhan DS, Todaria NP (1994) Allelopathy is Effect of weed leachates on germination and expected to be an important mechanism in the plant radicle extension of some food crops. Indian Journal Invasion Process 37: 177-179.
24. Shikha R, Jha AK (2016) Allelopathic activity of Parthenium hysterophorus L. leaf extract on Pisum sativum. International Journal of Recent Scientific Research 7: 9461-9466.
25. Shikha R, Jha AK (2016) Species composition and shoot biomass production in Parthenium dominated abandoned fallowland. IOSR Journal of Pharmacy and Biological Science 11: 41-47.

Citation: Sorecha EM, Bayissa B (2017) Allelopathic Effect of *Parthenium hysterophorus* L. on Germination and Growth of Peanut and Soybean in Ethiopia. Adv Crop Sci Tech 5: 285. doi: 10.4172/2329-8863.1000285