Pure Appl. Biol., 9(1): 309-319, March, 2020
http://dx.doi.org/10.19045/bspab.2020.90036

Research Article

Allelopathic effect of *Ailanthus altissima* on wheat (*Triticum aestivum* L.)

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Citation
Zakir Ullah, Syed Inzimam Ul Haq, Shah Khalid, Khalid Kamran, Amir Khan and Sheraz Ahmad. Allelopathic effect of *Ailanthus altissima* on wheat (*Triticum aestivum* L.). Pure and Applied Biology. Vol. 9, Issue 1, pp309-319. http://dx.doi.org/10.19045/bspab.2020.90036

Received: 02/05/2019 Revised: 15/09/2019 Accepted: 24/10/2019 Online First: 06/11/2019

Abstract

The allelopathic potential of *Ailanthus altissima* L. was investigated against *Triticum aestivum* L. variety Atta habib in the laboratory. Dry and fresh plant materials of *Ailanthus altissima* at 5g, 10g and 15g weight were soaked in 100ml distilled water. The materials were filtered after 24 hrs (1st treatment), 48 hrs (2nd treatment) and 72 hrs (3rd treatment). The extracts were applied to wheat grain to investigate their impact on radicle length, germination percentage and plumule length after 72 hours of incubation at 26°C. The result revealed that the extrect of fresh and dried leaves of *Ailanthus altissima* L. had inhibitory effect on germination percentage, plumule length and radicle length of *Triticum aestivum* . As compared to germinaton percentage, radicle and plumule length was more affected. The inhibitory effect of dried leaves on the test plant was more pronounced than the fresh leaves. The most inhibitory treatment which effect radicle length was 15g dry leaves extract in 48 hours sokaing duartion, which reduced the radicle length up to 0.67 mm, as compared to control (18.2 mm). The most inhibitory treatment which effect plumule length was 10g dry leaves extract in 48 hours soaking duration, which reduced the plumule length up to 0.26 mm as compared to control (7.8 mm). Germination percentage was also induced by 10g dry leaves extract in 48 hours soaking duration which reduced germination percentage to 13.33% as compared to control (100%). The reported inhibitory effects suggests the presence of some kinds of allelochemicals in *Ailanthus altissima* L. inhibited the germination and growth of the wheat.

Keywords: *Ailanthus altissima* L.; Allelopathy; Germination percentage; Inhibitory effect; Plumule length; Radicle length; *Triticum aestivum* L.

Introduction

Ailanthus altissima L. is a medium sized tree which extend to a height between 17 and 27 meters (56 and 89 ft). The diameter is about 1 meter (39 inches) at breast height **[1]**. *Triticum aestivum* L. belongs to Poaceae family. It is cereal grain and is cultivated worldwide. Wheat is the most produced crop in the world after maize and rice. The production of wheat is estimated to about 691 million tons per year. As compared to other crops, it is grown on more area and is

considered the most important food crop in the world. The trade of wheat is more than any other crop plant [2]. In 1937 an Austrian scientist, Molisch coined the term allelopathy which is a compound of two Greek words, allelon which means 'mutual' and pathos means to suffer. Allelochemicals may be defined as the beneficial or harmful effects of one plant on another plant through the release of biochemicals. Those allelochemicals which are having negative effects plays an important role in the defence of plant against herbivory [3, 4]. Allelopathy involves the ecological communications between species [5]. Secondary metabolites of the plants that are responsible for the allelopathic potential of the plants are known as allelochemicals. De Candolle [6] was the first person which proposed that there is a possibility that many plants may extract something from their roots which may be injurious to other plants. Allelochemicals are a subset of secondary metabolites not required for growth and development of the allelopathic organism. Anjum [7] studied the allelopathic effect by using sandwich method of some selected medicinal plants on *lettuce* seeds. He selected fourteen medicinal plants of semi-arid plain areas and performed experiment in the laboratory using sandwich method to evaluate their allelopathic action. The inhibitory (toxic) and stimulatory (nontoxic) effects were evaluated and studied their effect on germination, radicle length, growth percentage of hypocotyls. Both effects were examined for hypocotyl growth of lettuce seeds under the influence of leaves. Though the inhibitory and stimulatory effect of leaves varied with the plant species. From the results it was concluded that *Broussonetia papvrifera* and *Albizia lebbeck* possessed strong inhibitory effect on *lettuce* radicle length and growth of hypocotyls. Nakafeero [8] evaluated the allelopathic potential for five multipurpose trees that are currently promoted for agro-forestry in Botswana: *Acacia tortilis*, *A. erubescens* and *Terminalia sericea* and it was established that leaves from each species contained a variety of phenolic compounds (flavonols, flavonones, anthocynins, coumarins, leucoanthocynins, tannins) and alkaloids (tertiary and quaternary alkaloids) in varying concentration which are having allelopathic activity against plants in their vicinity. Gomez-Aparicio [9] studied the allelopathic effects of invasive tree *Ailanthus altissima* on three native tree species; *Acer rubrum*, *Acer Saccharum* and *Quercus rubra* and observed their emergence of seedling, survival and growth. From the results it was evaluated that the allelopathic effects of *Ailanthus altissima* were proportional to the density of neighborhood *Ailanthus*, regardless of their size. In difference, the effects of *Ailanthus* were strongly influenced by distance from a tree, mostly dropping to zero within 5m from the trunk. Youngling [10] studied that wheat (*Triticum aestivum* L.) has allelopathic potential if used as a cover crop for weed control in various cropping system. Many researches showed that, among modern verities, there is a variable resistance potential against weeds. A large number of allelopathic compound have been identified in wheat, mainly belonging to the categories of phenolic acids, hydroxamic acid and short chain fatty acids. The negative effects of other crops under different agriculture production systems have been reported. Lin [11] studied the allelopathic effect of aqueous extract of *Aloe vera* leaf on initial seedling and germination of four crops; radish, lettuce, turnip and rice and re-rooting ability in sweet potato and rice. It was concluded that the germination showed no effect with the extract, but the root length and height of seedling was significantly promoted in all test crops. The number of roots was increased in turnip and lettuce. Beyond this the extract possessed stimulatory effects on re-rooting ability in sweet potato and rice seedling.

From the results it was suggested that the aqueous extract of *Aloe vera* leaf could be used as a natural regulator in plant growth, as it promotes initial growth of seedling and cutting in roots.

Materials and methods

Collection, drying, crushing and storage of plant material

Ailanthus altissima leaves were collected in February 2016. Some of plant leaves were separated and was dried in shade. The dried material was slightly crushed and stored in polythene bags for use in future. Fresh material was washed after collection and was chopped straight away for extract.

Relative toxicity of plant part

Aqueous extracts were prepared by soaking each 5g, 10g and 15g (dried and fresh separately) leaves in 100ml of distilled water for 24, 48, and 72 hours at room temperature. It was filtered, and the extracts were used as stock solution for future use. Distilled water was used against *Triticum aestivum* L. as control treatment. The apparatus used in the research was Beaker, Filter paper, Petri dishes, Titration flasks, Incubator, Refrigerator and Mortar and pestle. Petri dishes were lined with doubly folded Whatman No.1 filter paper. Each Petri dish was provided with 5 healthy grains of wheat that were placed at equal distance on the filter paper. Before using the wheat, seeds were put in water to check the viability i.e., the seeds that settled down in water are viable seeds. The seed bed i.e., filter paper was moistened with 3ml of plant extract or distilled water in case of control. These Petri dishes containing wheat grains were placed in incubator at $26^{O}C$ for 72 hours. Each treatment had 3 replicates. After 48 hours incubation period, the parameters were measured such as; Radicle length, Plumule length and Germination Percentage.

Results

Effect of 24 hours soaking duration extract on radicle length

The result showed that inhibitory effect of *Ailanthus altissima* were concentration dependent. As the concentration of fresh and dried leaves increased, reduction in the radicle length was more. It can be seen from figure 1 that dry leaves were more inhibitory than fresh leaves. Most inhibitory treatment was 10 g of dried leaves which reduced the radicle length to 1.33 mm as compared to control (18.2 mm). Second most inhibitory treatment was 15 g of both fresh and dried leaves, reducing the parameter to 5.6 and 5.8 mm respectively, followed by 10 g fresh (6.67 mm) and 5g dry leaves extract (6.2 mm) as compared to control. Least inhibition in the radicle length was reported in case of 5g of fresh leaves with a reduced value of 9.07 mm (Figure 1).

Effect of 48 hours soaking duration extract on radicle length

Figure 2 showed that all the treatment was inhibitory for radicle length. It is obvious from the figure that dry leaves extract was having more inhibitory effects on the radicle length. Most inhibition in radicle length was seen in 10g and 15g of dry leaves, reducing the radicle length up to 0.86 mm and 0.67 mm respectively, compared to control (18.2 mm). Ten-gram treatment of the fresh leaves was the least inhibitory treatment (8 mm) followed by 5g of fresh leaves (6.87 mm). The result showed that inhibitory effect is concentration dependent as we increase the concentration of fresh and dry material for extract the radicle length decreased in same manner (Figure 2).

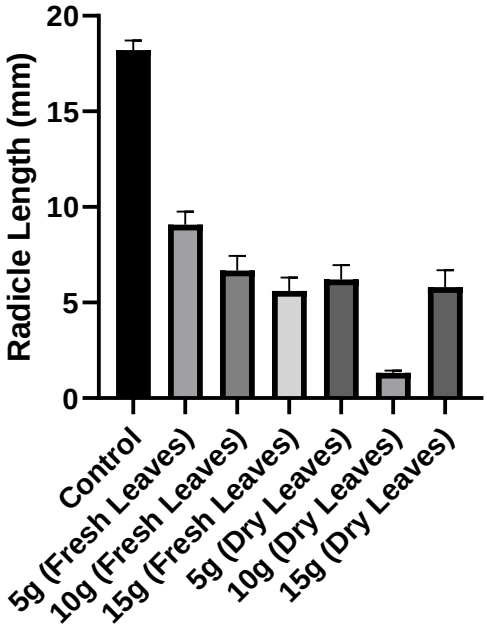

Figure 1: Effect of 24 hours soaking duration extract

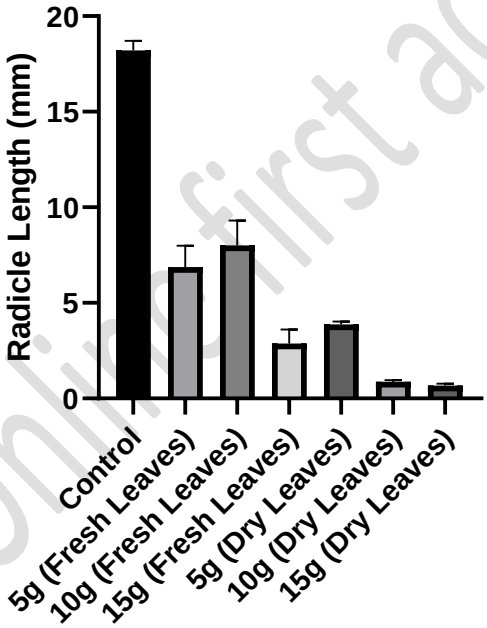

Figure 2: Effect of 48 hours soaking duration extract

Effect of 72 hours soaking duration extract on radicle length

The result showed that inhibitory effect of *Ailanthus altissima* are concentration dependent as the concentration of fresh and dried leaves increased, reduction in the radicle length was more. It can be seen from the figure 3, that dry leaves were inhibitory

than fresh leaves. Most inhibitory treatment was 10 g of dried leaves which reduced the radicle length to 2.867 mm as compared to control (18.2). Second most inhibitory treatment was 15 g and 5 g dried leaves extract, reducing the parameter to 3.16 mm and 3.94mm respectively, followed by 15 g fresh (4.07mm) and 10g fresh leaves extract (5.33mm) as compared to control (18.2 mm). Least inhibition in the radicle length was reported in case of 5g of fresh leaves with a reduced value of 7.2 mm (Figure 3).

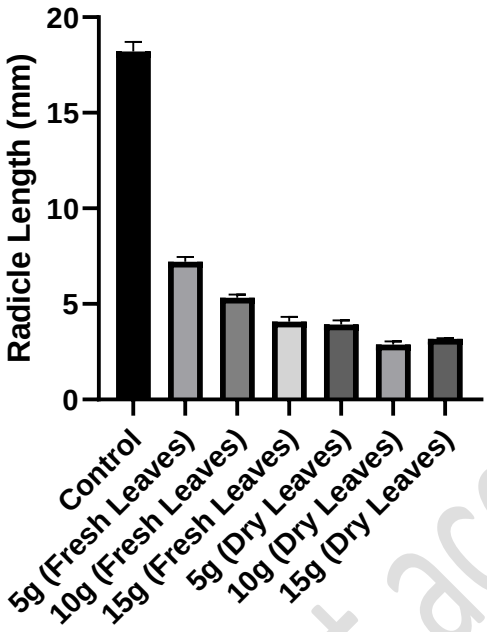

Figure 3: Effect of 72 hours soaking duration extract

Effect of 24 hours soaking duration extract on germination percentage

Extract obtained from 10 grams of dry leaves was the most reducing concentration for the germination percentage, reducing the parameter to 26.67%, compared to control (100%). Least inhibition in the germination percentage was seen in case of 10g extracts of fresh leaves followed by 15g of fresh leaves, which caused reduction in germination percentage up to 93.33% and 80% respectively while 5g fresh leaves extract was altogether without any effect. There was a different trend observed in the dry leaves extracts as most inhibitory treatment was 10g concentration (26.67%) rather than 15g, which reduced the percent germination to 53.33% (Figure 4).

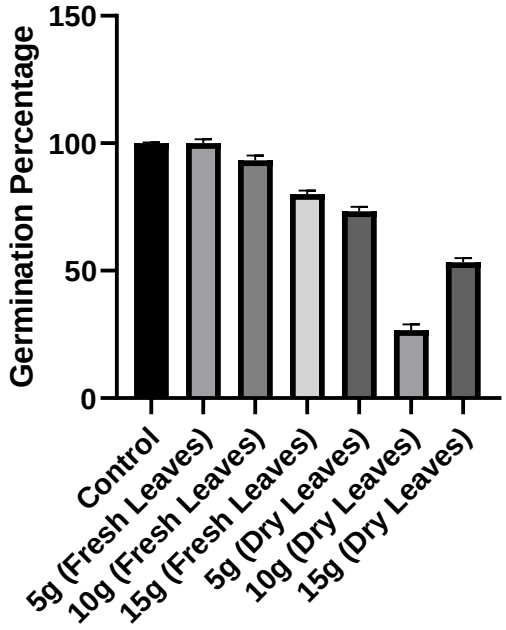

Figure 4: Effect of 24 hours soaking duration extract

Effect of 48 hours soaking duration extract on germination percentage

The data revealed that fresh leaves extracts was having very little effect on the germination of the wheat plant. In fresh leaves extract only reduction was caused by 15g leaves extract, with a reduction to 80% while 5g fresh leaves extract was altogether without any effect. Dry leaves extract was having a very pronounced effect on the germination percentage of wheat and the parameter was reduced to as low as 13.33% in case of 10g dry leaves extract. Second most inhibitory treatment was 15g of dry leaves. Effect of 5g dry leaves was similar to 15g fresh leaves and reduced the germination of wheat to 80% (Figure 5).

Effect of 72 hours soaking duration extract on germination percentage.

Extract obtained from 15g of dried leaves was the most reducing concentration for the germination percentage, reducing the parameter to 66.67% compared to control (100%). Least inhibition in the germination percentage was seen in case of 10g and 15g extracts of fresh leaves with a reduction up to 80% each, while 5g fresh leaves extract was altogether without any effect. Extract from 5g and 10g dried leaves were having the same reduction capability and reduced the germination to 73.33% each (Figure 6).

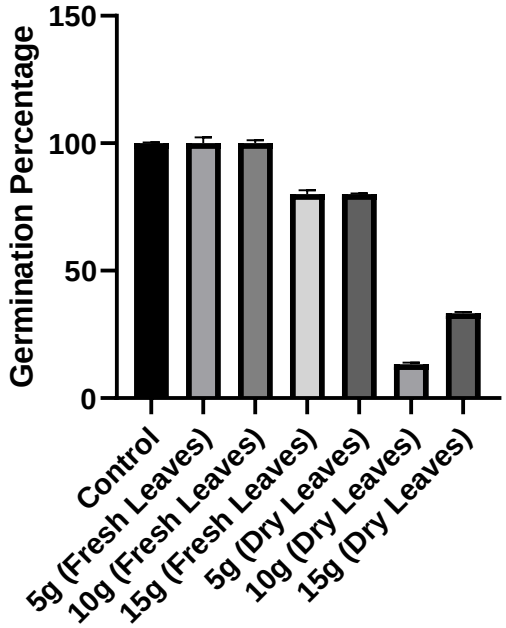

Figure 5: Effect of 48 hours soaking duration extract

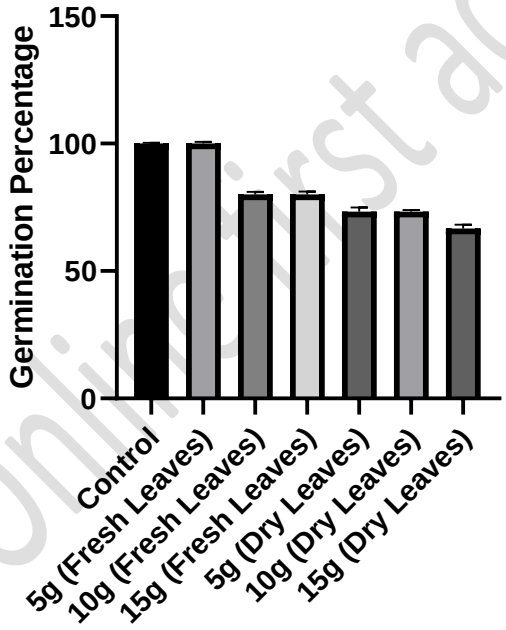

Figure 6: Effect of 72 hours soaking duration extract

Effect of 24 hours soaking duration extract on plumule length

The result showed that inhibitory effect of *Ailanthus altissima* are concentration dependent as the concentration of fresh and dried leaves increased, reduction in the plumule length was more. It can be seen from the figure 7, that dry leaves are inhibitory

than fresh leaves. Most inhibitory treatment was 10 gram of dried leaves which reduced the plumule length to 1.4mm as compared to control (7.8). Second most inhibitory treatment was 15 and 5 g dried leaves extract, reducing the parameter to 1.93mm and 4mm respectively, followed by 10g fresh (4.73mm) and 15g fresh leaves extract (4.93mm) as compared to control (7.8 mm). Least inhibition in the radicle length was reported in case of 5g of fresh leaves with a reduced value of 6.2mm (Figure 7).

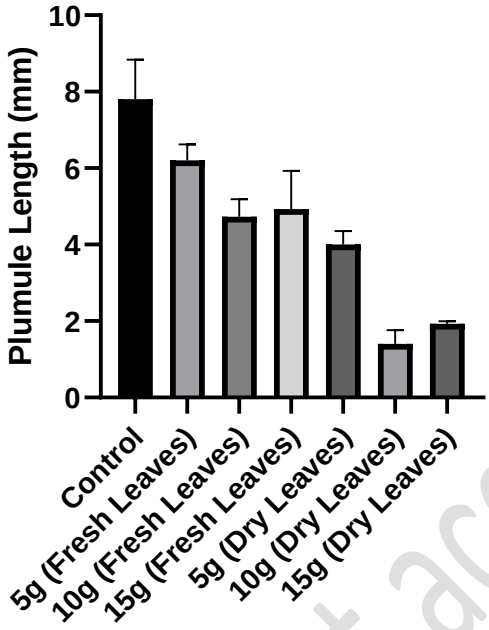

Figure 7: Effect of 24 hours soaking duration extract

Effect of 48 hours soaking duration extract on plumule length

The result showed that inhibitory effect of *Ailanthus altissima* are concentration dependent as the concentration of fresh and dried leaves increased, reduction in the plumule length was more pronounced. Most inhibitory treatment was 10g of dried leaves which reduced the plumule length to 0.26mm as compared to control (7.8). Second most inhibitory treatment was 15g in case of both fresh and dried leaves, reducing the parameter to 2.4 and 0.33mm respectively, followed by 5g dry (3.53mm) and 10g fresh leaves extract (4.53mm) as compared to control (7.8). Least inhibition in the radicle length was reported in case of 5g of fresh leaves with a reduced value of 5.2 mm (Figure 8).

Effect of 72 hours soaking duration extract on plumule length

The table shows that all the treatments were inhibitory for plumule length. It is obvious from the data that dry leaves extract having more inhibitory effects on the plumule length. Most inhibition in plumule length was seen in 15 and 10g of dry leaves, reducing the plumule length up to 1.86mm and 2.26mm respectively, compared to control (7.8 mm). Extracts from 15g fresh and 5g from dry leaves were having approximately the same inhibitory effects on the parameter with a reduction to 3.6mm and 3.33mm respectively. Five-gram treatment of the fresh leaves was the least inhibitory treatment

(5.8mm) followed by 10g of fresh leaves (5.4mm). The result showed that inhibitory effect is concentration dependent as we increase the concentration of fresh and dry material for extract the plumule length decreased in same manner (Figure 9).

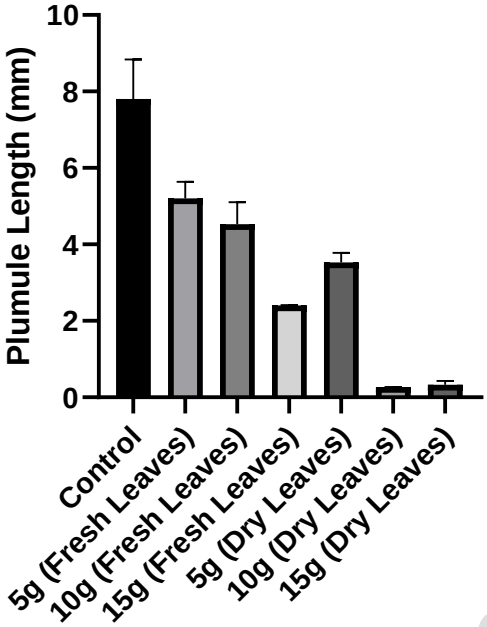

Figure 8: Effect of 48 hours soaking duration extract

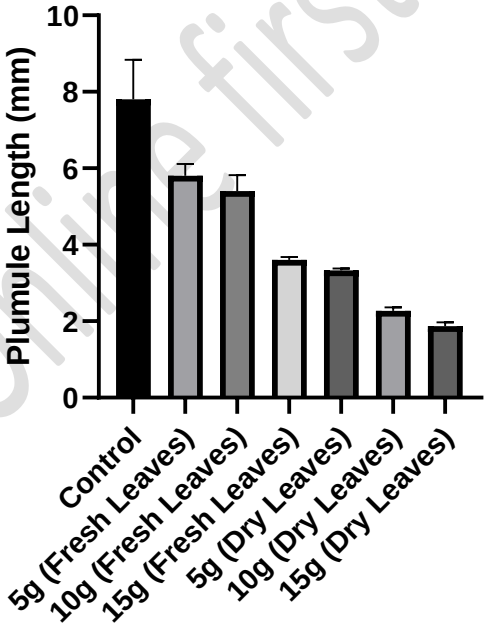

Figure 9: Effect of 72 hours soaking duration extract

Discussion

Ailanthas altissima—the tree of heaven—is reported to have allelochemicals that have significant potential against plants. The detailed worked conducted by Heisey (1990) showed that different extracts of this plant reduced the growth and development of other plants in the vicinity [12]. The current work was carried out to look for any potential allelopathic impact of this plant on wheat germination and growth. The overall results are surprising, as almost the treatments, that were aqueous extracts, were having a potential to reduce the germination percentage and growth of the wheat. These parameters were inhibited by extracts of almost all soaking durations, which clearly indicated that the chemicals are quickly released into the environment, irrespective of the duration of soaking [13]. The radicle length was inhibited with increasing concentration and soaking time. The dry leaves extract showed more inhibition in radicle length as compared to fresh leaves extract. The increased inhibition in radicle length was recorded in 10g dry leaves extract. It was also reported that fresh leaves were having less potential to reduce germination percentage, as compared to dry leaves, that may be due to the possible maturity of allelochemicals that are processed once the leaves are separated from the parent plant [14]. Another interesting phenomena was reported that out of 3 different concentration of extracts (5g, 10g and 15g), 10g extract was most inhibitory for germination percentage and growth of the plants, that was contrary to the general idea that with increase in concentration, negative impacts increase; rather the highest concentration extract i.e. 15g was stimulatory in its nature, as reported by some earlier workers. The effect of inhibition was enhanced with increasing plant material. The results showed similarity with results of Samreen [15], Ullah [16] and Hadi [17]. It's a general trend that allelochemicals may reverse its impact as per the concentration, as reported many times that increasing concentration some time cause positive effects, then negative [18, 19]. From the results it was found that there may be some toxic allelochemicals present in plant which cause growth inhibition and development. It is recommended that these allelochemicals are required to identified and quantified for further study on allelopathy.

Conclusion

Germination was most significantly reduced by 10 g extract of dry leaves and as the soaking duration increased his inhibitory effects increased. The maximum inhibitory effect was observed in 10 g extract of dry leaves followed by 15 g and 5 g. The most affected parts of *Triticum aestivum* were plumule followed by the radicle length. It is concluded the *Ailanthus altissima* leaves possess potential allelochemicals that are affecting germination percentage & inhibiting plumule and radicle length of the *Triticum aestivum*.

Authors' contributions

Conceived and designed the experiments: Z Ullah & SIU Haq, Performed the experiments: Z Ullah, SIU Haq & S Khalid, Analyzed the data: SIU Haq, S Ahmad, Z Ullah & A Khan, Contributed materials/analysis/ tools: SIU Haq, K Kamran & S Khalid, Wrote the paper: SIU Haq & S Khalid.

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