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RESEARCH ARTICLE

Allelopathy of *Parthenium hysterophorus* L. On Lettuce, Wheat and Selected Pathogens

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ABSTRACT

In allelopathy, plants can release different types of chemicals, which may affect other plants directly or indirectly, resulting in the inhibition of seed germination or plant growth. *Parthenium hysterophorus* L. is one of the most hazardous weeds that can broadly affect cultivated crops as well as wild types of plant species through allelochemicals. In this study, the allelopathic effect of *P. hysterophorus* on lettuce, wheat and some pathogens were explored. Various extracts of *P. hysterophorus* were obtained and then applied in different concentrations. Phytochemical analysis of different compounds was done using various qualitative and quantitative tests. After exposure of lettuce and wheat plants to seed extracts and root exudates of *P. hysterophorus*, the growth and length of leaf, stem and roots of the receiver plants were significantly affected. Moreover, *P. hysterophorus* exudates caused shrinkage with the thickness of the leaf, stem and root cells. The exudates of *P. hysterophorus* were also tested for their potential anti-microbial activities against *Escherichia coli, Klebsiella pneumoniae, Morganella morganii, Clavibacter michiganensis, Pseudomonas aeruginosa* and *Staphylococcus aureus*, but there were no zones of inhibition detected. According to the current study, the exudates of *P. hysterophorus* might contain potent allelochemicals, which can be used against weeds to achieve sustainable agriculture.

Key words:

INTRODUCTION

Molisch in 1937 used the word allelopathy, which is derived from the word allelon means "of each other" and pathos means "to suffer". These words are derived from the Greek language, which means the deleterious effect upon each other (Rizvi et al., 1992). It is assumed that in allelopathy the donor plant releases chemicals that can affect the growth and development of the receiver plant. In 1996 International Allelopathy Society (IAS) described allelopathy as "Any process involving secondary metabolites produced by plants, micro-organisms, viruses, and fungi that influence the growth and development of agricultural and biological systems (excluding animals), including positive and negative effects" (Torres et al., 1996). Allelochemical is a term used for allelopathic substances (Whittaker, 1970; Levin, 1976). The release of different types of chemicals from plant species is termed allelochemicals or allelochemics, which can be released through the primary metabolic pathway as secondary metabolites. Secondary metabolites as allelochemicals are produced through two biochemical pathways known as acetate and shikimate acid pathways. The allelochemicals may also play an important role in the defensive mechanism against different types of herbivores or plant

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pathogens (Einhellig, 1995). Allelochemicals may be released through different types of channels, like by root exudation, leaching, and volatilization and also by the decomposition of plant material (Rice, 1984).

Allelopathy mainly reduces seedling growth and seed germination. There is no physiological target site and common mode of action of allelopathy, while the known sites of action contain photosynthesis, cell division, pollen germination, nutrient uptake and some functions of enzymes (Kruse et al., 2000). There are different types of compounds involved in allelopathy, including carbohydrates, amino acids, phenolic, terpenoids, alkaloids, steroids, and flavonoids. For crops, one of the main risks leading to overwhelming plant growth and development in considerable amounts is weeds. Weeds can compete with crop plants for natural resources. There is a never-ending demand for food by the population, which is continuously growing with an increase in population. Therefore, the problem of weed is alarming at present and needs to be controlled (Haroon et al., 2023). Wild plants that rise in crop fields are frequently unwelcome because they fight with the cash crops for resources and ultimately decrease the crop yield. Though usually interfere with crop metabolism, they grow as an integral component of crops. It secretes substances, which hinder the development of other plant species in the vicinity. The majority of weeds through releasing chemical substances hamper the growth of main crops. They often affect the growth and germination dynamics of other crop species (Shoukat et al., 2024).

P. hysterophorus is an aggressive annual weed and has an allelopathic effect on other plants that can cause severe crop yield losses. It was originally thought to be spreading across tropical countries (Tamado et al., 2002). These land masses have penetrated diverse environmental and biogeographical zones over the last few years in more than 40 countries (Bajwa et al., 2016). *P. hysterophorus* produces different types of allelochemicals, including the sesquiterpene, lactones and parthenin, which have the functions of stimulation and inhibition of different plants and can also cause phytotoxicity to many cultivated and wild plants. These compounds are biosynthesized by *P. hysterophorus* throughout the life cycle. Almost all plant species can produce different types of allelochemicals, which can be developed in the primary stages of the life cycle or the entire life. These compounds might be poisonous to other plant or animal species. These allelochemicals are bioactive compounds that may affect the surrounding environment (Ahmed et al., 2023). There is a large number of bioactive microbial compounds in the wild-type plant species that might be used as a new source of antimicrobial activity after extraction. These resources can serve as folk medicinal plants, which were used in ancient times by the people in the form of herbs and spices. These foods can be used locally for the preservation of folk medicines. There is also a large number of herbs and spices that can be used as antioxidant and antimicrobial activities, like bactericidal and bacteriostatic.

P. hysterophorus is found in Pakistan almost in those places where temperatures range from 10 °C to 30° C (Fatimah and Ahmad, 2009). It also causes allergic problems like dermatitis and rhinitis in mammals (Singh et al., 2003). In traditional medicine, *P. hysterophorus* is used for the treatment of diarrhea, neurologic, urinary infections, dysentery and malaria (Fazal et al., 2011). The species of *P. hysterophorus* has 18 diploid chromosomes (Hakoo, 1963). *P. hysterophorus* has also a bioactive compound which is used to be pharmacological e.g. muscular rheumatism, vermifuge and therapeutic for neuralgia (Fazal et al., 2011).

The stem of *P. hysterophorus* is longitudinally grooved, the leaves are irregularly dissected, the flowers are axillary and the heads of the flowers are terminally and 5 mm in diameter. The fruit (seeds) of *P. hysterophorus* is dark brown (Kanchan and Jayachandra, 1976). The *P. hysterophorus* produces 25000 achenes (seeds) per plant in abandoned fields in Asia (Evans, 1997). Allelopathic nature is reported in the root and shoot of *P. hysterophorus* in which water-soluble phenolic and sesquiterpene lactones are present (Nath, 1988). Bioactive compounds which have been reported include Parthenin, Apigenin, Borneol, Camphor, Charminarone, Coronopilin, Luteolin, Parthenolide, α-Pinene, Reynosin, Santamarin, Santin, Tetraneurin-E, Caffeic, vanllic.

Objectives

- To investigate the allelopathic effects of *P. hysterophorus* root and seed coat exudates on lettuce and wheat seed germination.
- To evaluate the allelopathic effects of root and seed coat exudates of *P. hysterophorus* on some pathogens.
- To perform qualitative and quantitative tests for the presence of allelopathic compounds in *P. hysterophorus* root and seed coat exudates.

MATERIALS AND METHODS

Plant Collection

The seeds of *P. hysterophorus* were collected during the winter season (November-December 2018) from District Mardan, KP, Pakistan and were shade-dried at 28°C. The plants were identified and stored at the Herbarium of Botany Department at Abdul Wali Khan University Mardan, KP, Pakistan.

Extraction of Bioactive Compounds

Seeds of *P. hysterophorus* were washed thoroughly with 70% ethanol, which was followed by a sterile water wash thrice. The seeds of *P. hysterophorus* were taken in various quantities (0.1gm & 1gm), which were imbibed in 10 ml of double distilled water (ddH_2O). The root exudate was collected 20 days after the growth of the seedlings, which were used for phytotoxicity and anti-microbial activities. The falcon tubes were kept in a shaking incubator (200 rpm) for 3 days at 25-27 °C

having seeds in ddH_2O. The root exudate was collected after seedling growth of *P. Hysterophorus* in Petri plates and then transferred into plastic glasses having Hoagland solution for 20 days. The seed extract and root exudate were centrifuged and the supernatant was collected for different assays, like phytotoxicity and anti-microbial activities.

Allelochemicals Study

The allelopathic effects of seed extract and root exudates of *P. hysterophorus* were assayed on the lettuce and wheat.

Antimicrobial Activity

Human pathogenic bacteria were used for the antimicrobial assay which was provided by the Microbiology Lab, Abdul Wali Khan University Mardan, KP, Pakistan. These pathogens include *Escherichia coli, Klebsiella pneumoniae, Morganella morganii, Clavibacter michiganensis, Pseudomonas aeruginosa* and *Staphylococcus aureus*. The antibacterial activity was examined for Root and seed coat exudates by the agar well diffusion method against six pathogenic bacteria. For the determination of the zone of inhibition, the standard (control) antibiotics used include streptomycin, kanamycin, ampicillin, chloramphenicol, ciprofloxacin and cefixime. All the exudates were screened for their antibacterial activity against *E. coli, K. pneumoniae, M. morganii, C. michiganensis, P. aeruginosa, S. aureus*. Zones of inhibition were measured after 18 to 24 hours of incubation at 37 °C for bacteria. In measuring the zone of inhibition on media plates, the sizes of inhibitory zones (including the diameter of the disk), the sensitivities of the microorganism species to the plant extracts were determined, and values <8 mm were considered as non-active against microorganisms.

Test Plants and Microorganisms

Test plants used for this research are lettuce (*Lactuca sativa*) and wheat (*Triticum aestivum*) as well as human pathogenic bacteria *E. coli, K. pneumoniae, M. morganii, C. michiganensis, P. aeruginosa and S. aureus*. All the tested bacterial species were maintained on nutrient agar media.

Macroscopic Analyses

The percentage of germinated seeds was noted after 24, 48, 72, 96 and 120 hours of exposure to the treatments. The length of the root and shoot was measured after 120 hours (centimeter) and then the fresh weight (gram) of the root and shoot separately, which were then dried and recorded their dry weights.

Microscopic Analyses

Microscopic analyses of treated plants were performed. In the microscopic study the root, stem and leaf were examined of treated plants vs control.

Root and Shoot Length (RSL)

The root and shoot length were also measured (Centimeter) after 5 days.

Root and Shoot Fresh Weight (RSFW)

The root and shoot fresh weight (RSFW) of plants was measured when the lettuce and wheat seed were treated with different concentrations of *P. hysterophorus* seed extract and root exudate.

Root and Shoot Dry Weight (RSDW)

The root and shoot dry weight (RSDW) of plants were measured. The plants were wrapped in paper to dry and then the dry weight of the root and shoot were taken.

Preparation of Media

The LB Agar was prepared by taking 40-gram agar and dissolve in 1000 ml distilled water in conical flasks. The contents of the flask were then autoclaved on a liquid cycle (121 °C, 15 minutes). For the positive control, the media was supplemented with specific antibiotics in the flask. The liquid media was poured into the Petri plates inside the laminar flow hood.

Table 1.1: Ingredient of Luria Bertani Agar (LB Agar)

S. No	Ingredients	g/Liter
1	Tryptone	10g
2	Yeast extract	5g
3	NaCL	10g
4	Agar	15g

RESULTS

Percentage (%) Seed Germination of Lettuce and Wheat

The percentage (%) seed germination was recorded after five days, where the highest germination was observed in control of both lettuce and wheat plants, while the lowest germination was reported mostly in 0.1g of seed-extract treated samples but 1g of seed extract and root exudate nearly showed the same effect (Table 1.1-1.2). The 0.1g of seed-extract treated samples of Lettuce showed 6.66 % growth, while 1g of seed extract and root exudate showed 16.66 % and 13.33 % respectively. The 0.1g of seed-extract treated samples of Wheat showed 26.66 % growth, while 1g of seed extract showed 30 % and root exudate 50 % respectively (Table 1.2).

Table 1.1: Show percentage (%) seed germination of Lettuce seeds treated with seed extracts (0.1 and 1 gm) and root exudates of *P. hysterophorus*. The highest effect on Lettuce seed germination was observed in 0.1 gm (Green), while 1 gm seed extract (Brown) and root exudate (Yellow) showed about the same effect.

P. hysterophorus Extract	Total Lettuce Seed	Germinated Seeds	Germination (%)
Control	30	26	86.66%
0.1g seed extract	30	2	6.66%
1g seed extract	30	5	16.66%
Root exudate	30	4	13.33%

Table 1.2: Show percentage (%) seed germination of Wheat seeds treated with seed extracts (0.1 and 1 gm) and root exudates of *P. hysterophorus*. The highest effect on Wheat seed germination was observed in 0.1 gm (Green) followed by 1 gm of seed extract (Brown) and in root exudate (Yellow) the effect was lower than 0.1 gm and 1gm of seed extract.

P. hysterophorus Extract	Total Lettuce Seed	Germinated Seeds	Germination (%)
Control	30	28	93.33%
0.1g seed extract	30	8	26.66%
1g seed extract	30	9	30%
Root exudate	30	15	50%

Root and Shoot length (RSL) Graph of Lettuce

The root and shoot length (RSL) of lettuce were measured after their exposure to the root exudates and extract of seeds of *P. hysterophorus*. The RSL of lettuce was greatly affected by the bioactive compounds present in the extract of *P. hysterophorus* seeds and root exudates. The highest growth was recorded in the control plants, while the lowest growth was recorded in the plants exposed to seed extracts of 0.1 gm compared to 1 gm of seed extract and root exudates (Fig. 1.1). The RSL of lettuce is taken in centimeters (cm).

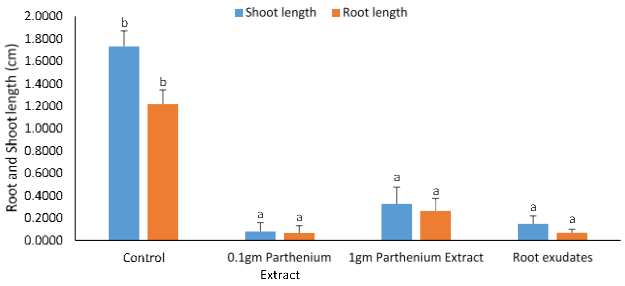

Fig. 1.1: Effect of seed extract a) 0.1 gm, b) 1 gm and c) root exudates on the root shoot length of Lettuce plants. Data are the means of 3-replicates with standard error bars. Different letter shows significant differences ($p < 0.05$).

Root and Shoot Fresh Weight (RSFW) Graph of Lettuce

The root and shoot fresh weight (RSFW) of lettuce was measured after their exposure to the root exudates and seed extract of *P. hysterophorus*. The RSFW of lettuce was greatly affected by the bioactive compounds present in the extract of *P. hysterophorus* seeds and root exudates. The RSFW of plants increases or decreases when the amount of concentration increases or decreases. The highest weight was recorded in the control plants but in control, the weight of the shoot was higher than the weight of the root while the lowest growth was recorded in the plants exposed to seed extracts 0.1gm as compared to 1gm seed extract and root exudates. 0.1gm seed extract has a greater effect on the weight of the lettuce plant (Fig. 1.2).

Root and Shoot Dry Weight (RSDW) Graph of Lettuce

The root and shoot dry weight (RSDW) of lettuce was measured after their exposure to the root exudates and seed extract of *P. hysterophorus*. The RSDW of lettuce was also affected by the bioactive compounds present in the extract of *P. hysterophorus* seeds and root exudates. The highest weight was recorded in the control plants but in control the weight of shoot was higher than root while the lowest weight was recorded in the plants exposed to seeds extracts 0.1gm as compared to 1 gm seed extract and root exudates (Fig. 1.3).

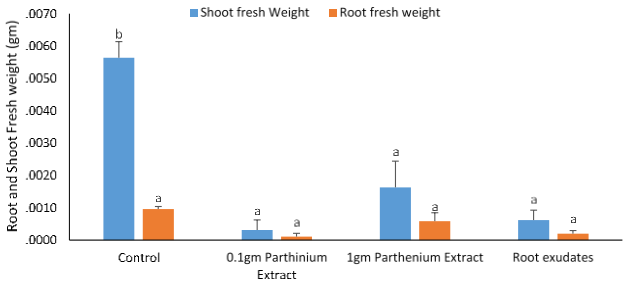

Fig. 1.2: Effect of seed extract a) 0.1gm, b) 1gm and c) root exudates on the root shoot fresh weight of Lettuce plants. Data are the means of three replicates with standard error bars. Different letters show significant differences ($p < 0.05$).

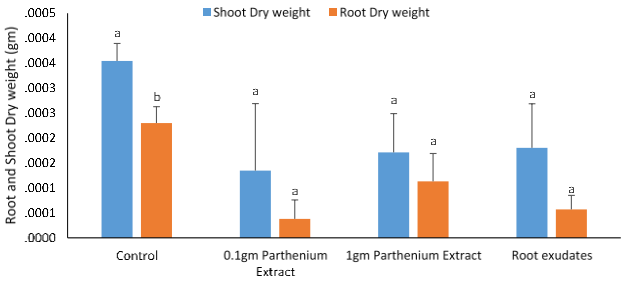

Fig. 1.3: Effect of seed extract a) 0.1gm, b) 1gm and c) root exudates on the root shoot dry weight of Lettuce plants. Data are the means of three replicates with standard error bars. Different letter shows significant differences ($p < 0.05$).

Root and Shoot Length (RSL) Graph of Wheat

The root and shoot length (RSL) of wheat were measured after their exposure to the root exudates and extract of seeds of *P. hysterophorus*. The RSL of wheat was greatly affected by the bioactive compounds present in the extract of *P. hysterophorus* seeds and root exudates. The highest growth was recorded in the control while in control the root growth was higher than the shoot of control plants while the lowest growth was recorded in the plants that were exposed to seed extracts 0.1 gm as compared to 1gm seed extract and root exudates. One gram of seed extract and root exudates were affected the same and the length of these affected wheat plants is the same (Fig. 1.4). The RSL of wheat was taken in centimeters (cm).

Root and Shoot Fresh Weight (RSFW) of Wheat

The Root and Shoot fresh weight (RSFW) of wheat was measured after their exposure to the root exudates and extract of seeds of *P. hysterophorus*. The RSFW of wheat was greatly affected by the bioactive

compounds present in the extract of *P. hysterophorus* seeds and root exudates. The RSFW of plants increases or decreases when the amount of concentration increases or decreases. The highest weight was recorded in the control plants but in control, the weight of the shoot was higher than the root weight while the lowest growth was recorded in the plants that were exposed to seed extracts 0.1gm and 1gm as compared to root exudates. The root of 0.1 g, 1g, and root exudate were almost of the same weight while the shoot weight of root exudate is higher than 0.1gm and 1gm (Fig. 1.5). The RSFW of wheat was taken in grams (gm).

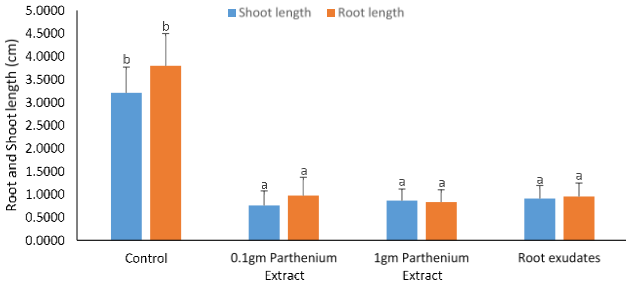

Fig. 1.4: Effect of seed extract a) 0.1gm, b) 1gm and c) root exudates on the root shoot length of wheat plants. Data are the means of three replicates with standard error bars. Different letter shows significant differences ($p < 0.05$).

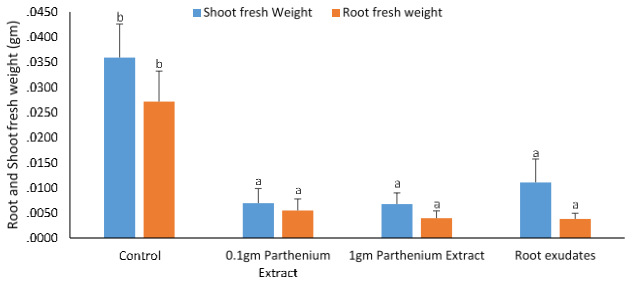

Fig. 1.5: Effect of seed extract a) 0.1gm, b) 1gm and c) root exudates on the root shoot fresh weight of wheat plants. Data are the means of three replicates with standard error bars. Different letter shows significant differences ($p < 0.05$).

Root and Shoot Dry Weight (RSDW) of Wheat

The root and shoot dry weight (RSDW) of wheat was measured after their exposure to the root exudates and extract of seeds of *P. hysterophorus*. The RSDW of wheat was greatly affected by the bioactive compounds present in the extract of *P. hysterophorus* seeds and root exudates. The highest growth was recorded in the control plants but in control, the weight of the shoot was higher than the root weight while the lowest growth was recorded in the plants exposed to seed extracts 0.1 gm compared to 1gm seed extract and root exudates (Fig. 1.6).

Microscopy of *P. hysterophorus* Lettuce and Wheat

Microscopic examination of the lettuce and wheat was done of different parts including leaf, stem and root treated with *P. hysterophorus* with seed extract as well as root exudate vs the control. This was done to check if any cytotoxic effects were caused by extracts treatment.

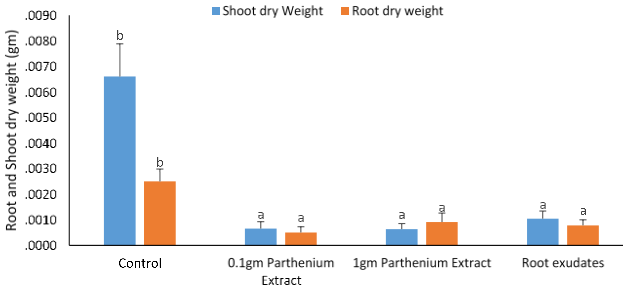

Fig. 1.6: Effect of seed extract a) 0.1gm, b) 1gm and c) root exudates on the root shoot dry weight of wheat plant. Data are the means of three replicates with standard error bars. Different letter shows significant differences ($p < 0.05$).

Microscopy of Lettuce

Control

The leaf, stem and root of control plants appeared normal and almost 100% seeds showed germination (Fig. 1.7-1.9). A 0.1 g seed extract has very high cytotoxic effect on lettuce. Most of the seed did not germinate, while the germinated one has affected root, shoot, length and weight and reduced cell size (Fig. 1.7). The 1 gm seed extract treated seed also showed cytotoxic effects on seed growth and root shoot length but comparatively less than that of 0.1 gm seed extract (Fig. 1.8). The root exudate of *P. hysterophorus* has cytotoxic effect on root shoot length as well as affect seed germination. The root exudate mainly affected the cell size and number of root hairs (Fig. 1.9).

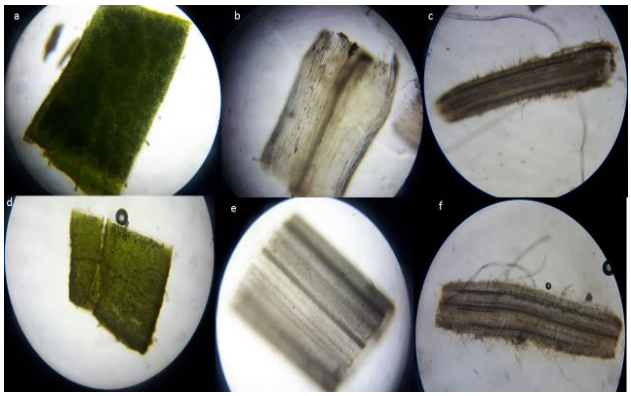

Fig. 1.7: Lettuce microscopic analysis of a) leaf b) stem and c) root of control plants and phytotoxic effect of 0.1g seed extracts of *P. hysterophorus* d) leaf e) stem and f) root.

Microscopy of Wheat

Microscopy has been performed of the leaf, stem and root of the untreated wheat plant (control) for comparative analysis with the treated plants (Fig. 1.10-1.12). The seed extract 0.1g of *P. Hysterophorus* showed high cytotoxic effect on wheat just like lettuce. The leaf, stem and root cell size were affected by 0.1g of

seed extract. Most of the seed lack germination, while the germinated plant's root shoot length and weight was also affected (Fig. 1.10). The 1g seed extract has comparative low cytotoxic effect on the seed growth and root shoot length of the germinated plant (Fig. 1.11). The root exudate of *P. hysterophorus* has cytotoxic effects on root shoot length as well as effect on seed germination (Fig. 1.12).

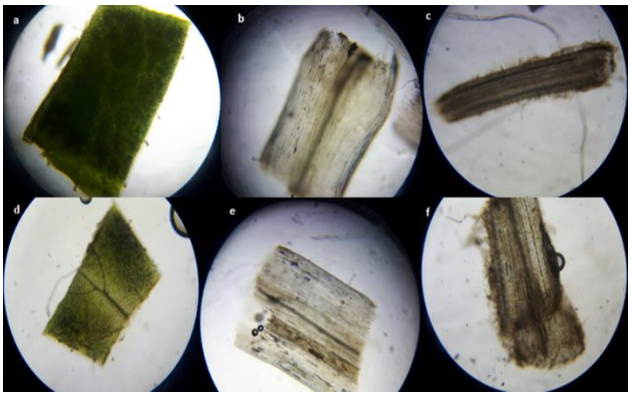

Fig. 1.8: Lettuce microscopic analysis of a) leaf b) stem and c) root of control plants and phytotoxic effect of 1g seed extracts of *P. hysterophorus* d) leaf e) stem and f) root.

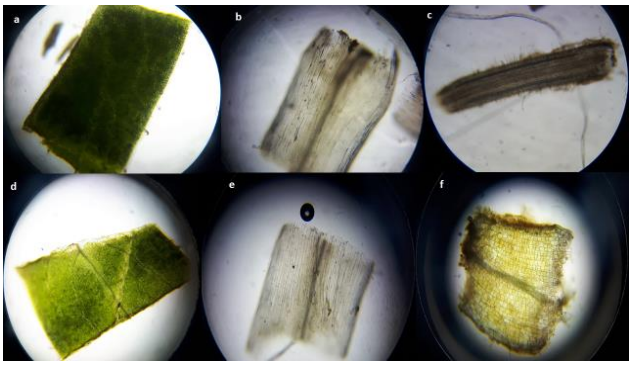

Fig. 1.9: Lettuce microscopic analysis of a) leaf b) stem and c) root of control plants and phytotoxic effect of root exudate of *P. hysterophorus* d) leaf e) stem and f) root.

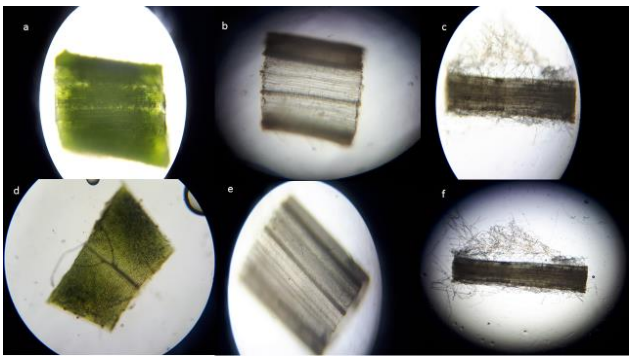

Fig. 1.10: Wheat microscopic analysis of a) leaf b) stem and c) root of control plants and phytotoxic effect of 0.1g seed extracts of *P. hysterophorus* d) leaf e) stem and f) root.

Anti-Microbial Activity

The antibacterial activity of *P. hysterophorus* was carried out by the agar well diffusion method. The media used for bacterial growth was LB agar. The seed extract and root exudate were used to check the antibacterial activity. Our analysis showed that *P. hysterophorus* seed extract or root exudate has no potential antibacterial activity. Antibacterial activity was performed on seed extract 1g and root exudate of *P. hysterophorus.* Standard anti-biotic used was streptomycin (2mg/ml) as positive control, while DDH_2O as negative control. The letter E on petri plates stand for seed extract or root exudate, S for Streptomycin and D for DDH_2O.

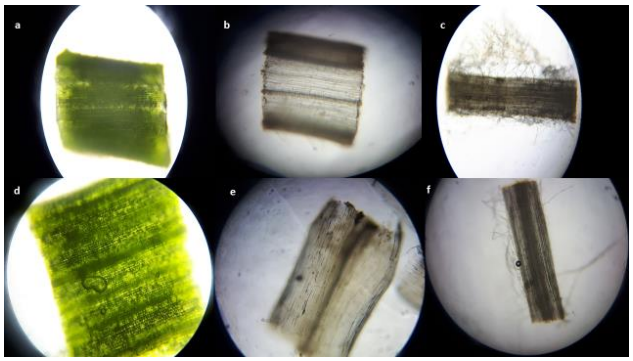

Fig. 1.11: Wheat microscopic analysis of a) leaf b) stem and c) root of control plants and phytotoxic effect of 1g seed extracts of *P. hysterophorus* d) leaf e) stem and f) root.

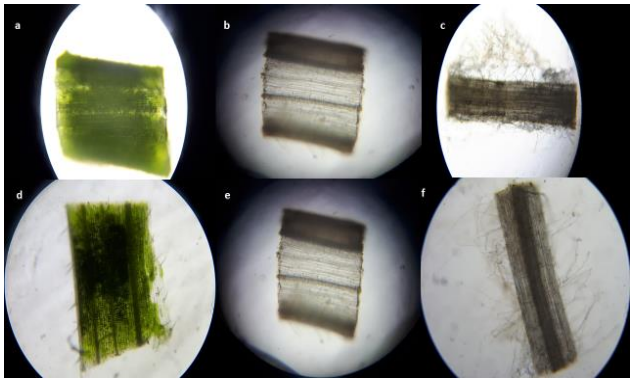

Fig. 1.12: Wheat microscopic analysis of a) leaf b) stem and c) root of control plants and phytotoxic effect of root exudate of *P. hysterophorus* d) leaf e) stem and f) root.

Clavibacter michiganesis

C. michiganesis is pathogenic bacteria, which cause "ring dot" disease in potatoes. The seed extract (0.1g) and root exudate of *P. hysterophorus* were applied to *C. michiganesis* but the zone of inhibitions was less than 8 mm so it was not considered as antibacterial. The streptomycin makes the inhibitory zone on the surface of media which is >8mm while there is also no inhibitory zone in DDH_2O (Fig. 1.13).

Escherichia-coli

Escherichia-coli is commonly human pathogenic bacteria which is highly resistance to antibiotic as well as seed extract 0.1g and root exudate of *P. hysterophorus*. There was no effect of seed extract 0.1g and seed exudate of *P. hysterophorus* on *E. coli.* (Fig. 1.14).

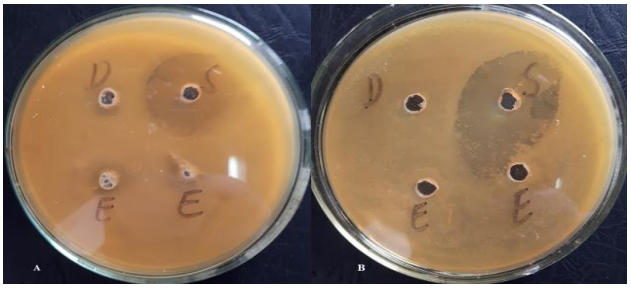

Fig. 1.13: A) *Clavibacter michiganesis* seed extract 0.1g, B) *Clavibacter michiganesis* root exudate.

Fig. 1.14: A) *E. coli* seed extract 0.1g, B) *E. coli* root exudate

Morganella morganii

It is also human pathogenic bacteria. There was no effect of seed extract 0.1g and root exudate on *M. morganii.* The positive control (streptomycin) showed visible zone of inhibition and negative control (DDH_2O) without any zone of inhibition (Fig. 1.15).

Fig. 1.15: A) *Morganella morganii* seed extract 0.1g, B) *Morganella morganii* root exudate.

Pseudomonas aeruginosa

P. aeruginosa was highly resistant to seed extract 0.1g of *P. hysterophorus*, while there was a small inhibitory zone in root exudate less than 8 mm. Therefore, we can't consider as inhibitory zone but it needs further analysis to confirm that it is resistant to *Pseudomonas aeruginosa* or not (Fig. 1.16).

Staphylococcus aureus

S. aureus was also resistant to seed extract 0.1g and root exudate based on the analysis of negative (DDH_2O) and positive control (streptomycin). Its mean there is no antibacterial activity of *P. hysterophorus* on *Staphylococcus aureus* (Fig. 1.17).

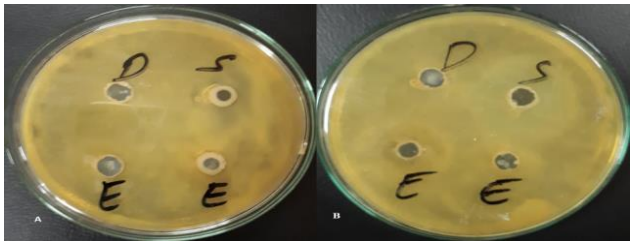

Fig. 1.16: A) Pseudomonas seed extract 0.1, B) Pseudomonas root exudate.

Fig. 1.17: A) *Staphylococcus aureus* seed extract 0.1, B) *Staphylococcus aureus* root exudate

Klebsiella pneumonia

K. pneumoniae was also highly resistant to seed extract 01g and root exudate because seed extract 0.1g and root exudate can't show any resistant or inhibitory zones (Fig. 1.18).

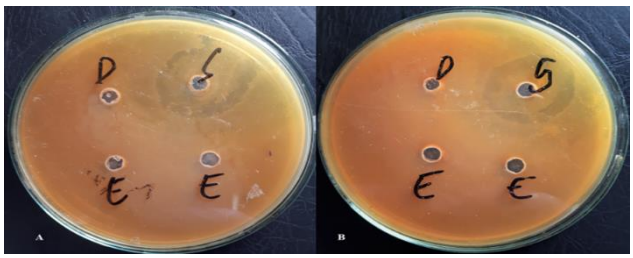

Fig. 1.18: A) *Klebsiella pneumoniae* seed extract 0.1, B) *Klebsiella pneumoniae* root exudate

DISCUSSION

Parthenium hysterophorus is poisonous, problematic and one of the seven worst weeds in the world which is a serious threat to cultivated crops and animal health (Tanveer et al., 2010; Kamarapu et al., 2015). It can grow in the wild and in those areas having a temperature range between 10°C to 25°C and throughout the year it has high germination ability (Tamado et al., 2002). *P. hysterophorus* has covered a lot of agriculture and cultivated land and affects them badly by releasing allelochemicals present in the *P. hysterophorus* plant (Navie et al., 1996). The results of *P. hysterophorus* indicate that this weed has a higher allelopathic ability (Kruse et al., 2000), which can inhibit the germination and growth of many cultivated crops and wild plants like vegetables, cereals, fruits and pasture grasses, etc. (Navie et al., 1996; Evans, 1997). The plant of *P. hysterophorus* contains Parthenin, which

is the major component while it also contains several other sesquiterpene lactones like alpha-methylene-gamma lactone which can play an important role in the bio-activity of the compounds that can help in the cytotoxicity and inhibit seed germination, plants growth, affect the root shoot length and weight of lettuce, wheat and others plants (Herz et al., 1962; Kruse et al., 2000).

The allelopathic effect of *P. hysterophorus* can also impact Lettuce (*Lactuca sativa*) and wheat (*Triticum aestivum*) which can inhibit the seed germination and plant growth, a decrease in root shoot weight and length of these plants (Wakjira et al., 2005; Karim and Forzwa, 2009). Lettuce and wheat are the main source of food which is affected by *P. hysterophorus* and it can cause many diseases to them (Wakjira et al., 2009).

Qualitative phytochemical analysis of *P. hysterophorus* extract can also provide the presence of different compounds like alkaloids, flavonoids, phenols, terpenoids and tannins while Saponins and steroids are absent. Saponins are absent in methanol extract and tannins are absent in ethanol extract while all other compounds are found in methanol and ethanol extract reported (Pandey, 2009; Deshpande et al., 2017). The bioactive compounds of *P. hysterophorus* are carbohydrates, phenols, proteins, and tannins for which quantitative tests are a positive and high number of compounds are found (Prabhavathi et al., 2016).

Microscopic analysis of the leaf, stem and root of lettuce and wheat plant which is highly affected and damaged by the extract of *P. hysterophorus* but in control, there is no such effect and damage detected as in the research study of (Moore et al., 1987) also discussed that the extract of *P. hysterophorus* also affect other plants and cause serious damages to other plants. Cells become elongated and shrunken when exposed to an extract of *P. hysterophorus*.

The presence of antimicrobial compounds is also reported in *P. hysterophorus* (Pandey, 2007). Antimicrobial compounds present in *P. hysterophorus* can kill or inhibit microorganism's growth. Seed extract 1g in DDH_2O and root exudate in Hoagland was used against different species of pathogenic bacteria for antibacterial assay but there is no inhibition zone was detected while the detected zone is less than the zone of inhibition in control which is less than 8mm in the research study of (Deshpande et al., 2017) the zone of inhibition is detected in the extract of methanol, ethanol and petroleum ether. In this research study seed extract 1g and root exudate showed zone of inhibitions, which were less than the inhibition zone in the positive control (streptomycin), which means that when the amount of seed extract or root exudate increases then the activity of bioactive compound also increases (Kamarapu et al., 2015).

Conclusion

The adverse effects of *Parthenium hysterophorus* on human and animal health are well known. Many researchers can use different techniques to take control of this toxic weed. *P. Hysterophorus* is a toxic weed that can release different allelopathic chemicals that can affect other plants. It can inhibit the germination of seeds, growth of roots and shoot of other plants by releasing different chemicals. In conclusion, there are many bio-active compounds present in the *P. hysterophorus* and it can affect the lettuce (*Lactuca sativa*) and wheat (*Triticum aestivum*). Different seed extracts and root exudates of P. Hysterophorus can inhibit the seed germination and growth of root and shoot of lettuce and wheat by releasing different toxic allelopathic compounds. Through Microscopy the effect of seed extracts and root exudate can also studied which has a great effect on the cells and the cells of lettuce and wheat become thick and shrunk. Anti-microbial assay on agar well diffusion can also be performed on the extract of seed and root exudate but there is no such activity is detected in the root exudate and seed extract (taken in DDH_2O). Due to the presence of different allelopathic compounds different tests of qualitative and quantitative analysis can be performed like alkaloids, flavonoids, steroids, tannins, terpenoids, etc. *P. hysterophorus* can be also used for medicinal values such as anti-microbial, anti-cancer, herbicide, pesticide, insecticide and also potent anthelmintic activity.

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