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Full Length Research Paper

Assessment of Allelopathic Potential of the Roots of *Parthenium hysterophorus* L. on Some Selected Crops

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Abstract. *Parthenium hysterophorus* L. is one of the fastest growing weed. It belongs to family Asteraceae. Parthenin is reported as a principle component of this plant and is responsible for allelopathy. Every year due to its luxuriant growth in the crop fields, as a weed it leads to destruction of thousand tons of crops around the globe. In the present study allelopathic effect of root extract (2%, 6% and 10 %) of *P. hysterophorus* on percent seed germination of 9 selected crops (*Brassica juncea*, *B. nigra*, *Coriandrum sativum*, Baby corn, F_1 hybrid beet, F_1 long radish, fenugreek, Japanese white radish), on its own seeds and its effects on the soil (control soil (garden soil), rhizosphere soil of *Parthenium* and leachet soil) was studied. After eight days of incubation at room temperature, it was found that among the nine plants Coriander Local Variety was most affected with zero percent seed germination with 2, 6 and 10 % of the root extract. Maximum percent of seed germination (80±10) was recorded with F_1 Hybrid Beet at 2%. *Parthenium* root extract was found auto toxic to its own seeds at 6 and 8% respectively. After 10 days of treatment, increment of pH from control soil (pH: 7.10) to rhizosphere soil of the *Parthenium* (pH: 7.28) was reported. Organic carbon, potassium and Nitrogen also follow the same trend whereas the EC (0.49%) and P (13Kg/hacters) were found maximum in root leachet soil.

Keywords: allelopathy, crops, *Parthenium*, root extract, seed germination

1. INTRODUCTION

Parthenium hysterophorus L. is one of the noxious members of the family Asteraceae (Kohli et al., 2006; Wakjira et al., 2009). It is native to America and had widely spread in all parts of the world (Khosla and Sobti, 1981; Aneja et al., 1991). In Ethiopia it was accidently introduced during 1970s. There are various assertions about its introduction in Ethiopia; the famous one is that it was introduced as contaminant of the American food aid during 1980s famine (Seifu, 1990; Tamado and Milberg, 2000). Later it spreads in all parts of the country with the food grains and was recognized as one of the fastest growing weed from grazing land to abandoned fields (Mekbib et al., 1996; Rezene et al., 2005; Netsere and Mendesil, 2011). For the first time its existence in India was documented by Roxburgh (1814). As per the beliefs *Parthenium* came to the India similar to that of Ethiopia under US PL 480 scheme and spread all parts of the India with the food grains (Kaur et al., 2014). As *Parthenium* grows in almost all climatic conditions and habitats such grass land, abandoned land and crop field and was reported as one of the most competent weed of the annual crops and leads to crop yield loss (Netsere and Mendesil, 2011).

This plant also shows a strong effect on both nitrogen fixing and nitrifying bacteria, leading to inhibition of the nodule growth in legumes because of its allelochemical potential (Kanchan and Jayachandra, 1980; Deyama, 1986). As per the reports the *Parthenium* secretes various chemicals on other plants such as phenolic acids, caffeic acid, vanillic acid, ferruclic acid, chlorogenic acid, para caumeric acid, para hydroxyl benzoic acid (Kanchan and Jaychandra 1980; Das and Das, 1995) and inhibits their growth. The chemicals released by a plant to inhibit the growth of the surrounding plants are known as allelochemicals. The second important allelochemicals are pseudoguaionolides which occur in shoot and root region. This pseudoguaionolides includes parthenin, anhydroparthenin, ambrosin, coronopilin, damsin which causes the cytotoxic, mitochondrial oxidative phosphorylation inhibition and allelopathic activity (Fay and Duke, 1977; Narasimhan et al., 1985; Picman, 1986; Pandey, 1996). Among these allelochemicals parthenin was reported as an active principle component of this plant

which possesses the strong allelopathic potential and allergic reactions (Bhowmik et al. 2007). As a result this weed leads to 40 % and 90 % loss in yield per annum in both agricultural crops and forage producing grasslands (Nath, 1988). In case of Sorghum crop 40 to 90% loss in yield was also reported (Tamado et al., 2002). In Australia alone this weeds was responsible for heavy loss which cost about $ 16 million per annum (ARMC, 2000). Due to its strong allergic and allelopathic potential it was reported to have hazardous effects on human health (Khosla and Sobti 1981; Rezene et al., 2005) and other animals (Chippendale and Panetta 1994; Tadesse et al., 2005). Besides invasion potential it also constitutes a number of secondary metabolites such as barbadin, β-Myrcene etc. which possess medicinal property (Damjanoviae-Vratnica et al., 2008).

So it was used in the treatment of inflammation, eczema, skin rashes, skin eruptions, skin tonic, fever, herpes, rheumatic pains, headache and ulcerated sores, muscular strains, as an analgesic, vermifuge, in heart trouble at various parts of the worlds (Towers et al., 1977; Bennet, 1985). But its invasion potential is greater than its medicinal benefits. As its allelochemicals leads to destruction of the crops, the current investigation was attempted to assess the allelopathic potential of the root extracts of *Parthenium hysterophorus* on 9 different selected cultivated crops and on its own plants (auto-toxicity) at *in vitro* followed by its effect on the rhizosphere soil the *Parthenium*, root leachet soil and the control soil (garden soil) *in vivo.*

2. MATERIALS AND METHODS

2.1 Collection of the Plant Material

The roots of *Parthenium hysterophorus* L. were collected from Uruli Kanchan (Lattitude: 18°50’44.18 N; Longitude: 74°13’23.88 E; altitude: 551m), Near Dattawadi ZP School, Haveli, Pune by individual and group visit randomly from 5-6 plants and were pooled together and were brought to laboratory for further experiment.

2.2 Preparation of root extract

The root extract from the collected roots of *Parthenium* was prepared using the protocol of Netsere and Mendesil (2011) with desired modifications. The root extract was filtered through Buchner funnel with Whatmann filter paper no.1 and was stored at room temperature under dark condition for 24 hours for further use. After 24 hours different concentration (2%, 6% and10%) of the root extract were prepared by adding double distilled water

2.3 Seeds

Seeds of the 9 different plants such as *Brassica juncea*, *B. nigra*, *Coriandrum sativum*, Baby corm, F_1 hybrid beet, F_1 long radish, fenugreek, Japanese white radish, *Parthenium hysterophorus* were purchased from Naik Seed Developers, Swargate, Pune, Maharashtra, India

2.4 Assessment of the allelopathic effect of the root extracts of *P. hysterophorus:*

To assess the allelopathic effect of the roots of *P. hysterophorus* on the seeds of 9 different plants, following parameters were studied

1. Effect of the root extract of *P. hysterophorus* on percent seed germination of the selected plant seeds *in vitro*.
2. Effect of the root extract of *P. hysterophorus* on the soil *in vivo*.

2.4.1. Effect of the root extract of *P. hysterophorus* on seed germination of the selected plant seeds (*in vitro*)

2.4.1.1 *Germination assay*

2.4.1.1.1 *Surface sterilization of seeds*

Ten seeds of each plant in triplicate were sterilized with 0.1 % $HgCl_2$ solution (0.5g $HgCl_2$ powder was dissolved in 500 ml distilled water) for 5 sec (Maharjan et al., 2007). The surface sterilized seeds were washed with sterilized distilled water in laminar air flow (Microfilt, India) 4-5 times before using for the germination assay.

2.4.1.1.2 *Seeding of the seeds in Petri plates for germination*

Three concentrations (2%, 6% and10%) of the root extract were used to check the allelopathic effect of *P. hysterophorus* on the sterilized seeds of 9 plants. In control distilled water was added. The seeds were aseptically planted in the sterilized Petri-plates (Borosil) with germination paper. All the three concentrations of the *P. hysterophorus* root extract were applied to the seeds of each plate (triplicate) except the control. All the plates were incubated at room temperature for 8 days. To keep germination paper wet each plate was watered (10ml) regularly under aseptic conditions. After 8^{th} day, the percent germination of the seeds, average (triplicate) and standard deviations were calculated using MS Excel 2007.

2.4.2. Effect of the root extract of *P. hysterophorus* on the soil *in vivo*

The root extract of the *P. hysterophorus* (10%) were mixed with plant free soil and its physicochemical analysis was carried out along with the rhizosphere soil of *Parthenium*, garden soil and normal soil (*P. hysterophorus* free soil) to check the level of allelochemical effect of the root extract of the *P. hysterophorus* on the soil. So, following key physicochemical characteristic of the soil (pH, electrical conductivity, N, P, K, Ca, Mg, Na, calcium carbonate, water holding capacity, moisture content, porosity, specific density, volume percent level, Salinity, type of soil) were submitted for the analysis at Govt. Soil and Water Testing Center, Agriculture College, Shivajinagar Pune, Pune.

Table 1: Effect of root extract (re) on the seed germination of the 9 different plants

Sr. No.	Plant	Treatment	% Germination			Average
			1	2	3	
1	F_1Hybrid Beet	Control	80.00	40.00	60.00	60.00±20.00
		2%	40.00	60.00	80.00	60.00±20.00
		6%	50.00	80.00	70.00	66.66±15.27
		10%	20.00	15.00	10.00	15.00±5.00
2	F_1 radish Long Red	Control	90.00	70.00	80.00	80.00±10.00
		2%	55.00	50.00	60.00	55.00±05.00
		6%	00.00	00.00	00.00	00.00±00.00
		10%	30.00	40.00	20.00	30.00±10.00
3	Japanese W. Radish-	Control	40.00	30.00	20.00	30.00±10.00
		2%	00.00	00.00	00.00	00.00±00.00
		6%	00.00	00.00	00.00	00.00±00.00
		10%	00.00	00.00	00.00	00.00±00.00
4	Coriander Local Variety	Control	80.00	40.00	60.00	60.00±20.00
		2%	00.00	00.00	00.00	00.00±00.00
		6%	00.00	00.00	00.00	00.00±00.00
		10%	00.00	00.00	00.00	00.00±00.00
5	Mustard Dhanlaxami Variety	Control	80.00	90.00	60.00	76.66±15.27
		2%	70.00	70.00	50.00	63.33±11.54
		6%	60.00	60.00	50.00	56.66±05.77
		10%	40.00	40.00	50.00	43.43±05.77
6	Methi Nisha Variety	Control	100.00	100.00	100.00	100.00±00.00
		2%	60.00	50.00	60.00	56.66±05.77
		6%	20.00	10.00	15.00	15.00±05.00
		10%	70.00	50.00	30.00	50.00±20.00
7	Carrot	Control	70.00	60.00	70.00	66.66±05.77
		2%	50.00	60.00	50.00	53.33±5.77
		6%	00.00	00.00	00.00	00.00±00.00
		10%	40.00	40.00	40.00	40.00±00.00
8	Mustard	Control	80.00	60.00	60.00	66.66±11.54
		2%	70.00	60.00	60.00	63.33±05.77
		6%	60.00	40.00	70.00	56.66±15.27
		10%	40.00	60.00	70.00	56.66±15.27
9	BaybyCorn	Control	100.00	70.00	70.00	80.00±17.32
		2%	70.00	70.00	70.00	70.00±00.00
		6%	100.00	60.00	60.00	73.33±23.09
		10%	40.00	60.00	60.00	53.33±11.54

2.5. Auto toxicity of the *Parthenium*

Allelopathic effect of the *Parthenium* root extract on its own seeds was also checked. Similar to other seeds treatment, *Parthenium* seeds were also treated with 2%, 6% and 10% of the *Parthenium* root extract and percent germination was determined along with the control.

2.6. Statistical analysis

All the experiments were performed in triplicates. The mean and standard deviation from the mean was calculated using MS Excel 2007.

3. RESULTS AND DISCUSSIONS

3.1 Assessment of allelopathic effect of the root extracts of *P. hysterophorus*

After eight days of incubation at room temperature the percent germination was calculated. The details of the percent seed germination plant wise given below:

1. F_1 hybrid beet root

The seeds of this plant showed least germination (15±5%) with 10% concentration of *Parthenium* root extract (Table 1).

2. F_1 Radish long red

This plant shows normal germination percentage in control, but at 6% 100 percent of inhibition (0.00±0.00 %) seed germination was recorded (Table 1).

3. Japanese white Radish

Strong allelopathic effect of *Parthenium hysterophorus* root extract was recorded in this plant at 2%, 6% and 10% concentration and 0.00±0.00 % germination was recorded (Table 1).

4. Coriander local variety

In 2%, 6% and 10% concentration seed shows the complete inhibition of seed germination (0.00±0.00 % germination) hence strong allelopathic effect was documented (Table 1).

5. Mustard Dhanlakshmi variety

The mustard seeds show the average germination percentage in control and 2%, 6% but in 10% concentration it leads to reduction (43.43±5.77%) in the germination percentage (Table 1).

6. Fenugreek (methi) Nisha variety

The seeds of fenugreek showed 100% germination in control treatment but minimum (15±5%) and maximum (56.33±5.77%) germination was recorded at 6% and 2% respectively (Table 1).

7. Carrot super caroda variety

The carrot root seeds recorded zero germination (0.00±0.00%) at 6% whereas at 2% (53.33±5.77%) germination was recorded (Table 1).

8. *Brassica* (Mustard)

The seeds of mustard also experienced allelopathic effect with the root extract of *P. hysterophorus.* Compared to control (66.66±11.54%) maximum reduction in percent seed germination was recorded (56.67 ±15.27) at 6% and 10 % (Table 1).

Table 2: Physiochemical analysis of the soils

Sr. NO.	Parameter	Type of soil		
		Control soil	Root leachet soil	Rhizosphere soil of Parthenium
1.	pH	7.10	7.10	7.28
2.	EC(misa cm)	0.26	0.49	0.21
3.	Organic Carbon (%)	0.24	0.78	1.05
4.	P (Kg/hectar)	11.84	13.00	12.94
5.	K(Kg/hectar)	651.65	683.34	1017.08
6.	N(Kg/hectar)	168.00	546.00	735.00
7.	Ca (%)	ND	ND	71.77%
8.	Mg (%)	ND	ND	20.11%
9.	Na (%)	ND	ND	3.20%
10.	CaCO3 (%)	ND	ND	5.25%
11.	Water holding capacity (%)	ND	ND	59.36%
12.	Porosity (%)	ND	ND	2.28%

ND: test Not done

9. F1 hybrid Baby corn seed

In Baby corn very little allelopathic effect was recorded interms of seeds germination. In control, the seeds recorded only 80±17.3% germination. The minimum (53.33±11.54) and maximum (73.33±23.09%) percent seed germination was documented at 2%, 6% and 10% concentration (Table 1).

Among the seeds of the 9 different plants maximum percent of seed germination was recorded in Baby corn (73.33±23.09) treated with 6 % root extract (Table 1). Whereas the seed of three plants (Japanese white Radish and coriander, Coriander PD Varity) shows zero percent of seed germination in all three treatments accept control (Table 1).

Table 3: Autotoxic activity of *Parthenium hysterophorus* L.

Treatment	% Seed Germination			Average
	1	2	3	
Control	10.00	15.00	20.00	15±5.00
2%	20.00	10.00	15.00	15±5.00
6%	0.00	00.00	00.00	00±0.00
10%	0.00	00.00	00.00	00±0.00

3.2. Effect of the root extract of *P. hysterophorus* on the soil *in vivo*.

After 10 days of the treatment the rhizosphere soil of *P. hysterophorus* along with garden soil and normal soil were analyzed. The physicochemical properties of a soil sample such as pH, electrical conductivity, organic carbon content, phosphorus (P), potassium (K), nitrogen (N), calcium (Ca) content, magnesium (Mg), sodium (Na), calcium carbonate, water holding capacity, porosity (Table 2) of the soils (control soil, root leachet soil and rhizosphere soil of *Parthenium*) reported the increment of pH from Control soil (pH: 7.10) to rhizosphere soil of the *Parthenium* (pH: 7.28). Organic carbon, K and Nitrogen also follows the same trend whereas the EC (0.49%) and P (13Kg/heacter) were found maximum in root leachet soil.

3.3. Auto toxicity of the *Parthenium*

The root extract at 2% do not shows any effect on the percentage of the seed germination whereas increasing concentration of the root extract leads to inhibition of seed growth and no seed germination was recorded (Table 3). The results (Table 3) show that *Parthenium* do possess the auto-toxic activity.

The present study documented the allelopathic potential of *Parthenium* root extracts on the percent seed germination of the nine selected crops (*Brassica juncea*, *B. nigra*, *Coriandrum sativum*, baby corn, F_1 hybrid beet, F_1 long radish, fenugreek, Japanese white radish). Further the physicochemical properties of soil, the process of root exudation, root leachates of the *Parthenium* is very important. By this process numerous secondary metabolites are released from the roots parts, they altered the physicochemical properties of soil, and this altered soil is due to secretion of allelochemicals, which enhance the constituent of soil by using mechanism of allelopathy. In the past (Maharajan et al., 2007) leaf extract of the *Parthenium* was used to assess the level of allelopathic effect on the seed germination and seedling growth of some selected cultivated species. They reported zero percent seed germination in *Zea mays* using 10 % aqueous leaf extract. Our result is in agreement with them, we also reported zero percent seed germination in case of Japanese w. radish and coriander local variety at all the three (2%, 6% and 10%) concentrations. Further Dogra and Sood (2012) also analyzed the phytotoxicty of *Parthenium hysterophorus* on three native plants of Himachal Pradesh under *in vivo* conditions and found that, soil mixed with residues of the Parthnium adversly affect the percent of seed germination and seedling growth. Recently Demissie et al. (2013) also studied the effect of root, shoot and leaf extract on the germination and elongation of onion and beans at Ethiopia. They also reported allelopathic effect of the *Parthenium* plant extract on the germination and elongation of the onion and beans respectively. Previously the allelopathic effect of *Parthenium* was also reported in *Brassica oleracea* (Kohli et al., 1985), *Zea maize* and *Sorghum* sp. (Tamado et al., 2002), multipurpose trees and arable crops (Swaminathan et al., 1990; Evans, 1997), *Eragrostis tef* (Tefera, 2002), *Cucurbita moschata* (Guzman, 1988), *Lactuca sativa* (Wakjira et al., 2005) and *Lycopersicon esculentum* (Mersie and Singh, 1988).

The root extract of the *Parthenium* also showed auto-toxic effect at higher concentration (6 and 8 %) and was also found in agreement with the previous reports (Chon et al., 2006; Kruse et al., 2000). They suggest that the allelochemical like coronopillin,

lactones, parthenin, and sesquiterpene were autotoxic to seedlings of *Parthenium*.

Physicochemical properties of soil of *Parthenium hysterophorus* is altered during releases of some secondary metabolites, allelochemicals by the process of root exudation and rhizosphere soil also shows high rate of physicochemical properties like electrical conductivity, pH, organic carbon, N, P, K, Ca++, Mg, free calcium carbonate, water holding capacity, moisture content, porosity, salinity etc and its comparison with normal soil and control soil (Dogra and Sood, 2012).

4. CONCLUSION

Based on the present study following conclusions can be drawn: (1) the root extract of the *Parthenium hysterophorus* do possess allelopathic effect, (2) besides affecting the other plants, this plant also reported autotoxic effect on its own species (3) *Parthenium* root produces allelochemical and leads to increase in the contents of organic carbon and nitrogen in the rhizosphere soil of *Parthenium* compared to that of control and root leachet soil (4) due to its strong allelopathic potential *Parthenium* may lead to huge loss of agricultural production per annum if not handled properly.

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