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Relative phytotoxicity of stem and root aqueous extracts of *Parthenium hysterophorus* L. on *Cicer aeritinum*

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ABSTRACT

The present study was conducted to evaluate the relative phytotoxic effects of different concentrations (15, 25, 50, 75 and 100%) of aqueous extract from stem and root of *Parthenium hysterophorus* on the rate of seed germination, length of root and shoot, and Seed Vigour Index (SVI) of *Cicer aeritinum*. In laboratory condition the experiment was set up in petri dishes, each petri dish contained ten seeds. Each treatment had ten replicates. A control condition was maintained using distilled water in place of stem or root aqueous extracts of *Parthenium*. The rate of seed germination in *Cicer aeritinum* in stem and root aqueous extracts of different concentrations decreased from 5% to 79%, and 0.0% to 22%, respectively. The inhibition value in root length in stem extracts varied from 11.14% to 85.96% and in root extract was from 13.14% to 64.25%. The inhibition in shoot length in stems and roots extracts varied from 14.67% to 50.19% and 73.68% to 85.86%, respectively. The Seed Vigour Index (SVI) value decreased from 16.38% to 94.99% in stem extract and 32.11% to 77.37% in root extract. The stem extract of *Parthenium* was more phytotoxic than the root extract in *Cicer aeritinum*. When the data collected were analysed using Tukey HSD and Post HOC Tests the phytotoxic impacts of plant parts (stem and root); treatments (15, 25, 50, 75 and 100% concentrations); and interactions between plant parts and treatments were highly significantly different at $p < 0.000$. Thus the present study indicated that the aqueous extracts of stem of *Parthenium* were recorded more phytotoxic than root extract on germination and growth of *Cicer aeritinum.*

Introduction

Parthenium hysterophorus L. is an exotic, invasive and noxious weed which has invaded more than 40 countries around the globe. Akter and Zuberi (2009) have indicated invasion as the most important threat on biodiversity after habitat destruction. Invasion is the global problem which is affecting the various continents adversely at different rates (Rai, 2015). Invasive species threaten global biodiversity, introduction of diseases, other ecological problems, and economic costs

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(Pimentel et al. 2005; Pysek and Richardson, 2010). The study of biological invasion will help in mitigation impacts of invaders and their basic principles of ecology and evolution (Sax et al. 2007). In India *Parthenium* has invaded all States (Kumar, 2015). The productivity of the crop is not only affected by *Parthenium* but animal health and human beings are also affected. In human beings it causes various types of allergies. *Parthenium* weed due to presence of parthenin, hysterin, hymenin and ambrosin causes and strong allelopathic effects on different crops. Parthenin has been reported as a germination and radical growth inhibitor in a variety of dicot and monocot plants (Gunaseelan, 1998). This weed affects nodulation in legumes due to inhibition of activity of nitrogen fixing and nitrifying bacteria. In India, *Parthenium* causes yield decline upto 40% in agricultural crops (Khosla and Sobti, 1981). There are reports that *Parthenium* extract affects the germination and growth of *Zea mays*, (Devi et al. 2014), *Triticum aestivum* (Kanchan and Jayachandra, 1980; Sarika et al. 2010), rice, wheat, chickpea, soybean and mustard (Biswas, 2000), and *Brassica* species (Singh et al. 2005).

Chickpea (*Cicer aeritinum*) is an important leguminous food grain. India is one of the largest producers of chickpea with about 63% of the total area under chickpea production lying in this country. It is a highly nutritious grain legume crop. It is a protein-rich supplement to cereal-based diets, especially to the poor in developing countries, where people are vegetarian or cannot afford animal protein. *Parthenium hysterophorus* is commonly found in disturbed sites, road sites, and fallow land. *Parthenium hysterophorus* has infested the nearby crop land. Thus the removal of this weed or management of crop land or fallow land has become problematic. It is reducing the crop productivity and income of the farmers. Earlier we have evaluated the effect of aqueous leaf extract of *Parthenium* on the rate of seed germination and seedling growth in *C. aeritinum* (Shikha and Jha, 2016a). The present work is the further extension of the phytotoxic effects of other parts (stem and root) of *Parthenium* on *C. aeritinum*. The present study was conducted to evaluate the relative phytotoxicity levels of different concentrations of aqueous extracts from stem and root of *Parthenium hysterophorus* on the rate of seed germination, length of root and shoot, and Seed Vigour Index (SVI) in *Cicer aeritinum*.

Materials and Methods

Parthenium hysterophorus has invaded the Jai Prakash University campus of about 240 ha area in just ten years. Earlier the whole area was a crop land. The study site is situated between 25^0 36'-26^0 15' N latitude and 84^0 25'-85^0 15' E longitude in the southern part of the newly created Saran Division of North Bihar. Total area of the Saran district is 2641 sq km.

After abandonment of cropping, *P.hysterophorus* invaded the whole area. Plant samples were collected from the University campus from vegetative phase of *P.hysterophorus* during the period 2017. Root and stem were separated and were air dried in shade and crushed by laboratory blender. Dried samples were powdered and were used in the conduction of the experiment. 15%, 25%, 50%, 75% and 100% concentrations were prepared. A separate control treatment was set up by using only distilled water. Experiments were set up in petri dishes covered with whatman's filter paper. For each treatment ten replicates were maintained and in each petri dish ten seeds of *C. aeritinum* were placed. Distilled water was added when needed in petri dishes. The rate of seed germination, length of root and shoot were determined after seven days of setting up of the experiment. Seed Vigour Index (SVI) was calculated by using this formula:

$$SVI = (Length\ of\ root + Length\ of\ shoot) \times Seed\ germination\ (\%)$$

Data collected were statistically analysed by using the SPSS programme through Pearson's Correlation Coefficient, and Tukey HSD and Post Hoc Tests.

Results and Discussion

The data recorded on the rate of seed germination, root length, shoot length and Seed Vigour Index (SVI) are presented in Table 1. The per cent decrease or increase in parameters studied in different concentrations of aqueous extracts of stem and root of *Parthenium* compared to control treatment are presented in Table 2, and summary of significance levels of plant parts, treatments and their interactions are presented in Table 3.

Seed Germination Rate (%)

In control treatment the rate of seed germination was recorded 100%. In different concentrations of stem extract of *P.hysterophorus* the rate of seed germination in *Cicer aeritinum* varied from 21% to 95%. In 15%, 25%, 50%, 75% and 100% concentrations of stem extract the seed germination rate was 95%, 79%, 79%, 64% and 21%, respectively. Maximum rate of seed germination was observed in 15% treatment and minimum rate in 100% treatment (Table 1). The rate of seed germination decreased by 5%, 21%, 21%, 36% and 79% in 15%, 25%, 50%, 75% and 100% treatments, respectively compared to control treatment. The rate of seed germination decreased with increase in the concentration of stem extract of *Parthenium* (Table 2). The rate of seed germination in *C. aeritinum* in control treatment and 15%, and 25% root extract of *Parthenium* was 100% whereas in 50%, 75% and 100% root extract these values were 99%, 99% and 78%, respectively. The rate of seed germination in 50% and 75% decreased by only 1% and in 100% treatment decreased by 22%. Thus except for 100% treatment there was no inhibitory effect of root

extract of *Parthenium* on seed germination in *C. aeritinum*. In 50% and 75% treatments there was only 1% decrease in the rate of seed germination (Table 2).

Table 1. Effects of different extract of *P.hysterophorus* on seed germination rate and growth parameters of of *C.aeritinum*.

Plant parts	Growth parameters	Control	15%	25%	50%	75%	100%
Stem Extract	Seed Germination (%)	100	95	79	79	64	21
	Root Length (cm)	8.26	7.34	5.5	3.9	3.11	1.16
	Shoot Length (cm)	2.59	2.21	1.81	1.29	1.43	1.43
	SVI	1085	907.25	577.49	410.01	290.56	54.39
Root Extract	Seed Germination (%)	100	100	100	99	99	78
	Root Length (cm)	6.77	5.19	5.86	4.86	3.84	2.42
	Shoot Length (cm)	3.04	0.65	0.8	0.75	0.55	0.43
	SVI	981	584	666	555.39	434.61	222.3

Table 2. Per cent increase or decrease in seed germination rate and growth parameters of *C.aeritinum* in different concentrations of *P.hysterophorus*.

Plant parts	Growth parameter	15%	25%	50%	75%	100%
Stem Extract	Seed Germination (%)	-5	-21	-21	-36	-79
	Root Length (cm)	-11.14	-33.41	-52.78	-62.35	-85.96
	Shoot Length (cm)	-14.67	-30.12	-50.19	-44.79	-44.79
	SVI	-16.38	-46.78	-62.21	-73.22	-94.99
Root Extract	Seed Germination (%)	0	0	-1.0	-1.0	-22
	Root Length (cm)	-23.34	-13.44	-28.21	-43.28	-64.25
	Shoot Length (cm)	-78.62	-73.68	-75.33	-81.91	-85.86
	SVI	40.47	-32.11	-43.39	-55.7	-77.37

Root Length (cm)

In stem extract of *Parthenium* in control condition the root length value was recorded 8.26 cm. In different treatments these values ranged from 1.16 cm to 7.34 cm being minimum in 100% treatment and maximum in 15% treatment. The per cent decrease in root length values in 15%, 25%, 50%, 75% and 100% treatments, respectively, were 11.1%, 33.4%, 52.8%, 62.3% and 86.0% compared to control treatment. The root length value was inhibited by 86% in 100% treatment and 11.1% in 15% treatment. In root extract of *Parthenium* in control treatment the root length value was recorded 6.77 cm whereas in 15%, 25%, 50%, 75% and 100% treatments these values were 5.19, 5.86, 4.86, 3.84 and 2.42 cm, respectively. The root length value in 15%, 25%, 50%, 75% and 100% treatments decreased by 23.34%, 13.44%, 28.21%, 43.28% and 64.25%, respectively.

Shoot Length (cm)

The shoot length values of *C. aeritinum* in different treatments of stem extract of *P.hysterophorus* ranged from 1.29 cm to 2.21 cm being minimum in 50% treatment and maximum in 15% treatment. In control treatment this value was recorded 2.59 cm. The per cent decrease in shoot length compared to control condition in 15%, 25%, 50%, 75% and 100% were recorded, respectively, as 14.7%, 30.1%, 50.2%, 44.8% and 44.8%. In root extract of *Parthenium* in control treatment the shoot length value was recorded 3.04 cm. In different treatments shoot length values varied 0.43 cm in 100% treatment to 0.8cm in 25% treatment. The per cent decrease in shoot length values in 15%, 25%, 50%, 75% and 100% treatments were 78.62%, 73.68, 75.33%, 81.91% and 85.86%, respectively compared to control treatment.

SVI

The seed vigour index value was recorded 1085 in control treatment in stem extract of *Parthenium* and in different treatments this value ranged from 54.39 to 907.25, which were minimum for 100% and maximum for 15% treatment. The per cent decrease in SVI values in different treatments compared to control treatment were 16.4%, 46.8%, 62.2%, 73.2% and 95%, respectively, in 15%, 25%, 50%, 75% and 100% treatments. In root extract of *Parthenium* in control treatment the SVI value was 981 whereas in different treatments it was minimum 222.3 in 100% treatment and maximum 666 in 25% treatments. SVI value decreased by 40.47%, 32.11%, 43.39%, 55.70% and 77.34% in 15%, 25%, 50%, 75% and 100% treatments, respectively, compared to control treatment.

The Tukey HSD and Post HOC Tests indicated that the effects of plant parts i.e. stem and root extract of *Parthenium* showed significant differences in the rate of seed germination, root length and shoot length in *C. aeritinum*, Similarly the effect of different concentrations of stem and root extracts of *Parthenium* showed significant differences in the rate of seed germination, root length and shoot length values in *C. aeritinum*. The interaction of plant parts i.e. stem and root extracts and treatments i.e. 15%, 25%, 50%, 75% and 100% concentrations were significantly different for seed germination, root length and shoot length of *C. aeritinum* (Table 3).

In the present study the rate of seed germination in stem and root aqueous extract of *Parthenium* varied from 21% to 95% and 78% to 100%, respectively in chickpea. In stem aqueous extract the rate of seed germination decreased with increase in the concentration of stem extract of *Parthenium*. The decrease in seed germination in stem extract varied from 5% to 79%. However, in root extract the rate of seed germination decreased from 1% to 22% only. In chickpea for seed

germination stem extract was more phytotoxic than the root extract of *Parthenium*. In the stem extract of *Parthenium* reduction in root length varied from 11.14 to 85.96% whereas in root extract it varied from 13.44 to 64.25%. Thus, root length in chickpea was more affected by stem extract than the root extract of *Parthenium*. The per cent decrease in shoot length and SVI values in chickpea varied from 14.67 to 50.19% and 16.38 to 94.99% in stem extract; and 73.78 to 85.86% and 32.11 to 77.37% in root extract of *Parthenium*.

Table 3. Significance levels of plant parts of *P.hysterophorus* at different concentrations on seed germination and growth parameters of *C.aeritinum* after Tukey HSD and Post HOC Tests.

Significance level no.		Seed Germination Rate (%)	Root Length (cm)	Shoot length (cm)
1	Plant Parts	0.000*	0.000*	0.000*
2	Treatments	0.000*	0.000*	0.000*
3	Plant Parts × Treatments	0.000*	0.000*	0.000*
4	Stem × Root	0.000*	0.945	0.000*
5	Control / 15%	0.995	0.038*	0.000*
6	Control / 25%	0.160	0.001*	0.000*
7	Control / 50%	0.100	0.000*	0.000*
8	Control / 75%	0.001*	0.000*	0.000*
9	Control / 100%	0.000*	0.000*	0.000*
10	15% /25%	0.415	0.792	0.998
11	15% /50%	0.296	0.000*	0.989
12	15% /75%	0.007*	0.000*	0.921
13	15% /100%	0.000*	0.000*	0.050*
14	25% /50%	1.000	0.021	1.000
15	25% / 75%	0.549	0.000*	0.995
16	25% / 100%	0.000*	0.000*	0.150
17	50% / 75%	0.685	0.353	0.999
18	50% / 100%	0.000*	0.000*	0.214
19	75% / 100%	0.000*	0.000*	0.404

*Significantly different

Earlier Shikha and Jha (2018a) have recorded decrease in seed germination in stem extract of *Parthenium* in *Cajanus cajan* from 5 to 62%; whereas root length, shoot length and SVI values decreased, respectively, from 25.62 to 63.33%; 1.05% to 25.72% and 18.1 to 79.7%%. Similarly in root extract the rate of seed germination, root length, shoot length and SVI values decreased by 1 to 22%; 57.61 to 87.12%; 20.05 to 79.01% and 25.24 to 85.86%, respectively in *C. cajan*. Thus, it indicated that the stem extract of *Parthenium* was more phytotoxic for chickpea than the *C. cajan* whereas root extract of *Parthenium* was more phytotoxic for *C. cajan* than chickpea. It clearly indicated that the phytotoxic effect of *Parthenium* is species specific. Oudhia and Tripathi (1998) have also reported allelopathic effects of *Parthenium* on the rate of seed germination and growth of

seedlings in chickpea. Earlier we have recorded the phytotoxic impact of aqueous extracts of leaves, stems and roots of *Parthenium* on the rate of seed germination and growth of seedlings of *Phaseolus mungo*, *Cicer aeritinum*, *Pisum sativum*, *Cajanus cajan*, *Macrotyloma uniflorum*, *Triticum aestivum*, *Zea mays* and *Brassica nigra* (Shikha 2018; Shikha and Jha 2016 a, b, c, d; 2017 a, b; 2018 a, b, c, d). The impact of plant parts, treatments and their interactions were highly significantly different at $p < 0.000$.

Conclusion

The present study indicated that the phytotoxic impact of aqueous extracts of stem and root of *Parthenium* differed significantly in chickpea. The cause of difference in phytotoxicity levels of stem and root aqueous extracts of *Parthenium* may be due to presence of different amounts of phytotoxin in stem and root of *Parthenium*. On the basis of present study it can be concluded that the aqueous extract of stem of *P.hysterophorus* was more phytotoxic to the rate of seed germination, length of root and shoot and Seed Vigour Index (SVI) in chickpea than the root extract of *Parthenium*. The phytotoxic impacts of *Parthenium* is species specific, it varied from species to species of crop plants.

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Conflicts of Interest

No conflicts of interest have been declared.

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